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ıe Nation's 'ater Resources

ıne Second National Water Assessment by the U.S. Water Resources Council

April 1978

Part II Water Management Problem Profiles

U.S. Water Resources Council 2120 L Street, N.W. Washington, D.C. 20037

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WATER ASSESSMENT.

PART II

WATER MANAGEMENT PROBLEM PROFILES

FOREWORD

The United States Water Resources Council was established by the Water Resources Planning Act of 1965 (P.L. 89-80) to maintain a continuing study and issue periodic reports on the Nation's water resources and their ability to meet present and future requirements. The results of the First National Water Assessment were issued by the Council in 1968 in The Nation's Water Resources. The First Assessment placed in a national perspective the estimates of present and future water and related land supplies and requirements of the Nation's water resources regions.

The Council initiated the Second National Water Assessment in October of 1974. In the analysis of the data the base year is 1975 and projections are made for 1985 and 2000. The United States has 21 water resources regions which for the purposes of the Second National Water Assessment were divided into 106 subregions. Comprehensive data and information were developed for each subregion. The subregion concept is to have one basin or a group of basins for which data could be collected and compiled.

Data collection and development of information for this report were conducted in three major phases: Phase One, Nationwide Analysis; Phase Two, Specific Problem Analysis; and, Phase Three, National Problems Analysis.

The Nationwide Analysis was conducted by Council member agencies and reflects their view of existing and future water requirements, the nature of problems, conflicts associated with efforts to meet the requirements, and implications for the future.

The Specific Problem Analysis was conducted on behalf of the Council by a regional entity in each of the 21 water resources regions. Each entity was comprised of a study team of representatives from state and Federal agencies. The Specific Problem Analysis viewed resource conditions and problems from a state-regional perspective.

The National Problems Analysis used the results of Phases One and Two to assess national problems for presentation in this report. The format is to present an overview of water resource management problems at the national, regional, and subregional level of detail.

An important feature of the Second National Water Assessment is that it presents a general "water balance" analysis for each of the 106 subregions. In these analyses the location and scope of critical water quantity, quality, and related land problems are indicated, as well as basic information needed for water and land management policies and programs.

The Nation's Water Resources, the final report of the Second National Water Assessment, is based on many reports and special studies. The Nationwide Analysis was documented in a summary report and 14 supporting appendices. The Specific Problem Analysis was documented by three published reports prepared by the 21 regional study groups; the State/Regional Future Report, Effect of Not Resolving Problems, and Summary Report.

The Nation's Water Resources includes the following parts and appendices:

Summary Report

Part I Introduction

Part II Water Management Problem Profiles

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Part IV Water Supply and Water Quality Considerations

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PART II

WATER MANAGEMENT PROBLEM PROFILES

Introduction

The primary concern of this part of the Second Assessment has been the identification of significant location and condition in relation to water resources problems in terms of their current and future requirements. The problems presented here emerged from an extensive survey of the current and potential water situation in each of the Nation's 21 regions and 106 aggregated subregions.

Regional sponsors representing Federal-State organizations, states, and the public in each region were asked to develop a list of existing and future problems as perceived by the diverse interest within the region. The sponsors delineated problem areas, examined problem interrelationships, and classified problems according to nationally consistent criteria. Problems were screened and categorized as being appropriately handled by ongoing Federal, state, or other programs or not being handled adequately. Problems were characterized as severe, moderate, or minor. The results of these analyses are presented in the Regional Reports supporting Part 5, Regional Assessment Summaries.

The hundreds of problems cited were tabulated and analyzed by the Water Resources Council, and approximately 100 were presented to regional, state, and Federal agency representatives. Following the discussions, a selected set of 17 preliminary water resources problem statements was developed and presented at the National Conference on Water in St. Louis, Missouri, on May 23-25, 1977.

Most frequently identified problems from the regional analyses included water quality, related land conflicts, water shortages, floods, and erosion and sedimentation.

From these studies, analyses and discussions, ten problems of national significance were selected for analysis. They are:

1. Inadequate water supply
2. Ground water depletion
3. Surface water pollution
4. Ground water contamination
5. Domestic water supply contamination
6. Flooding
7. Erosion and sedimentation
8. Dredge and fill
9. Drainage
10. Bay, estuary and coastal waters degradation

The impact of each of these problems was examined with respect to the public health, environmental quality, economic efficiency, resource conservation, international relations, pervasiveness, and urgency. The problems and their implications and potential consequences are presented in the following sections.

Although presented separately, the problems are interrelated. For example, ground water and surface water, erosion and dredging, drainage and water quality all interact. Any solution for one problem has an impact on others and effective planning for water resources must be broad enough to encompass these interrelationships.

The emphasis in the following presentations is on physical resource problems. Legal and institutional aspects, such as water rights, land use planning, water conservation, policy and organization, data and information, research, and public participation are included in the consideration of the recommended options for resolution of these problems.

Each problem profile serves to define a problem and shows where it has major impact in the United States. Also, the implications of the problems are identified along with specific problem examples and options for dealing with the particular problem. The purpose of this technique is to increase awareness at all levels. It is believed that if a problem is understood, the program emphasis may be directed to meet it. At a later time a follow-up assessment could evaluate progress toward problem resolution.

These chapters indicate that this Nation already has and is facing serious water management problems. In view of the long lagtime needed for planning, research, education, and implementation of programs aimed at resolving conflicts, it is our view that a comprehensive, coordinated program is vital to long term National well-being.

INADEQUATE WATER SUPPLY

Problem Definition

It has become evident that in most of the United States water is a scarce resource; scarce in the sense that not everyone can use as much as he wants under the prevailing conditions. Competition for water is a fact. Tradeoffs must be considered seriously. In some cases restrictions on use may be required. Water can no longer to be a "free good" for everyone.

In approximately 70 percent of the 106 aggregated subregions several municipal and rural domestic surface water supply shortages have been identified (Figure II-1). Almost every region west of the Mississippi River has indicated an inadequate supply of surface water for the food and fiber production at present output efficiencies and quantities.

Recently has there been an increased recognition that water left within a stream is not necessarily "unused." Instream requirements for recreation and fish and wildlife uses, in addition to the more traditional ones such as for hydroelectric energy development and transportation, are being given increased consideration.

New hydroelectric energy developments, until recently, was thought to be limited essentially to peak power production, i.e. modification of existing structures to take greater advantage of flows and pump-storage units to create even greater peaking capabilities. Now, with the cost of alternative energy sources continuing to rise, conventional and low-head hydroelectric developments appear to be economically feasible. Dependence

Inadequate Water Supply

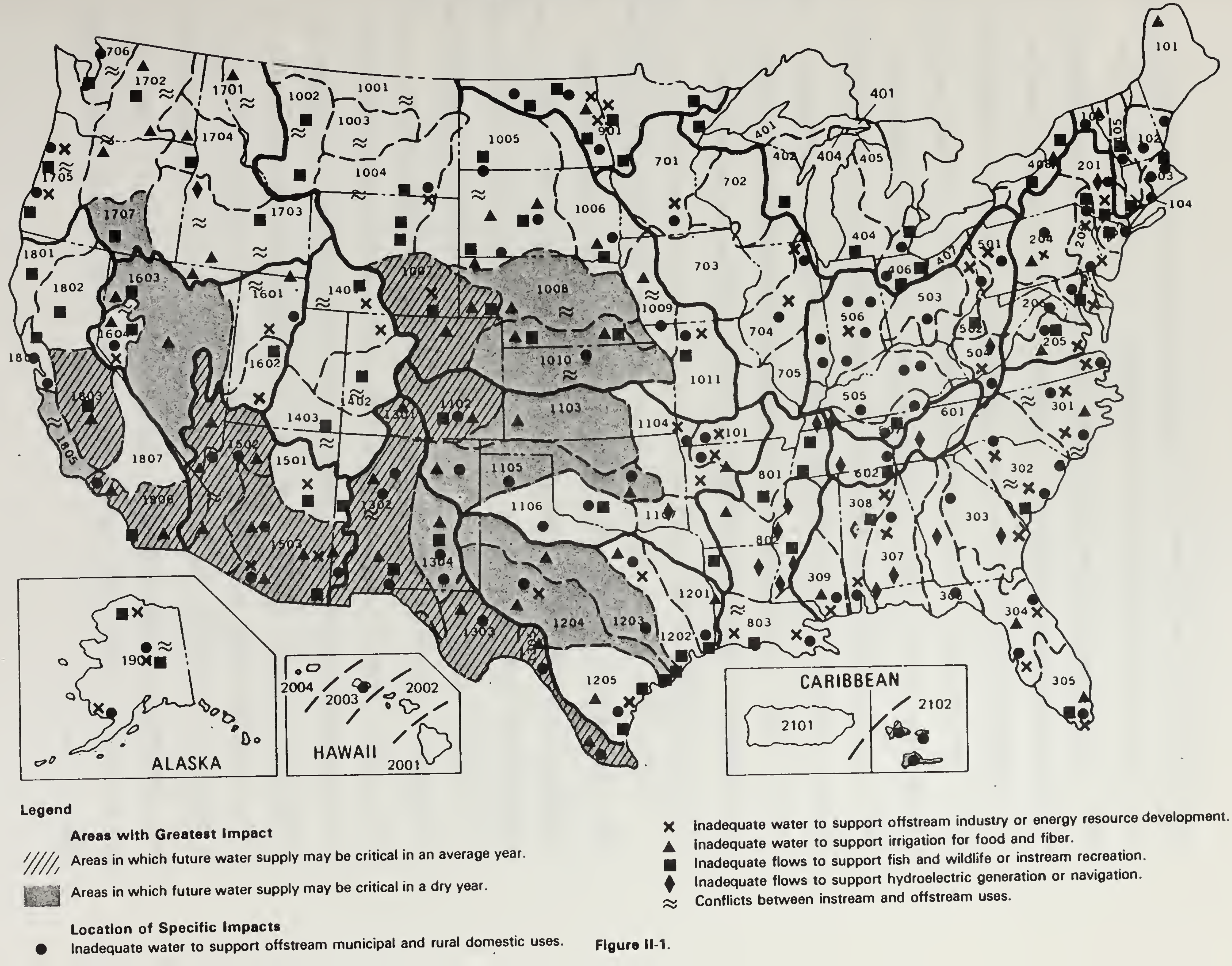


Figure II-1.

upon hydroelectric developments for increased peaking capabilities will cause serious conflicts with other uses because of stream flow regulation. Rapid fluctuations in stream levels that will occur under those circumstances will cause problems for recreation, navigation, and the aquatic ecosystem.

Droughts are normal climatological phenomena. There is no capability yet to forecast their occurrence with certainty, nor (once they are upon us) how long they will last. It is clear that no part of the Nation is immune to the possibility of drought. Even the humid East has experienced drought, although long-term droughts of several years duration are rare. Usually the East experiences very short-term seasonal periods of drought. The Northeast drought of 1962-1966 was an event expected on the average only once every 150 years.

During the 1930s the Great Plains were beset by abnormally low precipitation. In combination with high winds and extreme temperatures--compounded by years of overgrazing and generally poor farming techiquesgreat dust storms developed and much of the land lay useless for many years. In the late 1940s and early 1950s a drought occurred in the Southwest and southern midcontinent, lasting in some parts of the Southwest for more than ten years. Even though the drought of the early 1950s was more severe than the one in the mid 1930s the impact was far less severe nationally. This was because the national economy was stronger and could more easily absorb the loss, and conservation programs caused many areas to be less vulnerable. In 1976-1977, the Nation was again beset by drought, which centered in the West, Northwest, and upper midwest; with locally dry areas in the humid East as well. In some areas, precipitation levels were well below the lowest of record.

Implications

Throughout the Nation plans are being made for increased water use and, when those expectations are summed up, it becomes evident that in many areas, if the present use patterns continue, there will be severe conflicts. Furthermore, no simple solutions are available.

Demand for municipal and rural domestic water appears to be an increasingly serious problem, a situation related to population distribution. Some communities are restricting water connections, zoning land use, and defeating bond issues for water supply projects. Recent court cases have required communities to develop extensive conservation plans, including waste water reclamation, before further large-scale importation schemes may be implemented.

With increasing concern for national energy independence, major new developments for oil, coal processing, and mining operations can be expected. Where water supply is already limited, a transfer of water from an existing use or through importation will be required. In the West this transfer will almost inevitably be from irrigated agriculture. It is apparent that energy producers are willing to pay a far greater price for water per unit than irrigators. Retirement of irrigated farmlands, however, will result in a loss of agricultural production, a decline in rural lifestyle, and an increased concentration in urban centers. On the other hand, limiting energy development and industrial growth because of inadequate water supplies could result in higher unemployment, emigration, and economic hardship for some regions and the Nation.

A conservation program which would increase the efficiency in use of irrigation water could provide water for alternative uses such as energy production. However, some conservation actions such as a move toward sprinkler systems will require additional electric energy. Furthermore, the shift from flood irrigation to sprinklers, in some areas, has reduced ground water recharge. With declining ground water levels, increased pumping efforts (and increased energy use) is required.

There is an interaction between water quantity and water quality is clear. With increased consumptive use, streamflows will continue to be reduced. In some places this may mean that return flows and sewage effluents will constitute an increasing portion of stream volumes. Without a parallel effort to solve the water quality problem there could be increased public health problems. Fish and wildlife and water-related recreation activities could suffer. In many rivers of the East today water quality problems are evident as a result of reduced flows. With increasing off-stream uses and urban concentrations this problem will intensify.

Conflicts between flow regulation and downstream water uses could have major interstate and international implications. Problems of personal safety and economic losses may develop. Without adequate instream flows a loss of energy efficient navigational transportation could result in higher costs of transportation and consumer products. The use of hydroelectric plants for greater peaking production could result in more intensive flow regulations. For example, discharges from reservoirs may fluctuate radically in short periods to match changing energy demands. The resulting rapid rising and falling of flow levels could be a safety hazard to water recreation, cause navigational problems, and aggrevate already sensitive aquatic situations. The concept of using hydro-electric facilities for power peaking purposes has been assumed almost without argument.

The existence of adequate average flows does not mean that they will be usuable for offstream purposes without regulation. Irrigation, in particular, requires that the water be available when needed. Inevitably this means regulation by dams and reservoirs. Ponding the flows will, in most of the Nation at least, cause greater evaporation and consequent flow reduction. Flows below the impoundments will be reduced, and the distribution changed.

Specific Problems

The following representative specific problems illustrate the distribution and variety of problems. The information was furnished by Regional Sponsors.

Lower Colorado River (Region 15)

Overallocation of Existing Supply

The water supply available for use in Arizona and California from the lower Colorado River main stem consists of (1) natural runoff originating in the adjacent tributary area, (2) a portion of the main stem Colorado River water released from the Upper Colorado Region at Glenn Canyon Dam under provisions of the Colorado River Compact and operating criteria agreements, and (3) ground water. Direct water reuse is becoming increasingly important.

The Colorado River System is one of the more water deficient river systems in the Nation, and over half the population of the West is dependent on its meager and poorly distributed supply. Current water uses exceed available renewable supplies. The difference is presently being obtained by overdraft of the ground water supply in central Arizona and southern Nevada. Ground water levels are declining an average of eight to ten feet per year. Withdrawn water is used mainly for irrigation. Almost half of the irrigated acres in the region depend entirely on dwindling ground water supplies.

The average annual supply of the Colorado River soon will be inadequate to meet treaty and compact requirements. The Mexican Water Treaty of 1944 provides for delivery of 1.5 million acre-feet annually to Mexico. Surface and ground water supplies are insufficient to meet present uses, and aquifers are being overdrafted. As ground water levels drop, problems of increased pumping costs, land subsidence, and earth fissures become more prevalent. A major water quality concern stems from high levels of dissolved mineral salts.

Sacramento Valley (ASR 1802)

Conflict Between Present Recreation Use and Future Irrigation Use

The major water issue in this California problem area concerns flow levels in the Lower American River. Since the completion of Folsom Dam, minimum summer and fall flows have been several times greater than would have occurred during pre-dam conditions. As a result, this increased flow has provided much improved instream conditions for recreation and the fishing in general. This improved flow regime will be available only during an interim period until withdrawals for authorized project purposes build up. Unfortunately for recreationists, releases of the magnitude to which they have grown accustomed are not included in the authorization. There is considerable organized agitation to obtain increased minimum flows for the future.

Beaumont-Port Arthur Metropolitan Area (ASR 1201)

Conflict Between Irrigation Use and Downstream Water Quality

Large quantities of water are required by industries in Jefferson County in southeastern Texas for cooling, for boiler water, for various manufacturing and refining processes, and other industrial uses. The City of Beaumont supplies water to several Beaumont area industries. The major supplier of industrial water for the Jefferson County industries is the Lower Neches Valley Authority.

During the rice-growing season, the Lower Neches Valley Authority diverts water from its intakes on the Neches River and Pine Island Bayou to irrigate about 78,500 acres of rice in Jefferson County and portions of Liberty and Chambers Counties. This water is diverted across the basin divide and is used and discharged in the Neches-Trinity Coastal Basin.

The tidal reach of the Neches River extends from its mouth on Sabine Lake, where it intersects the Sabine-Neches Canal, to a temporary salt water barrier at river mile 37. During certain periods of the year, however, the withdrawals of fresh water from the Neches River and Pine Island Bayou equal the actual flow of the river. The result is a practically no-flow condition in the Neches River below the fresh water intakes. In the absence of fresh water inflow, without a barrier saline water moves uninhibited up the Neches River. This salt water intrusion makes it necessary for the Lower Neches Valley Authority to construct temporary sheet piling barriers across the Neches and across Pine Island Bayou to prevent salt water from reaching their intakes. These barriers effectively block all flow in the river with the exception of flood flows, which occasionally wash out the barriers. The barriers are normally required during the late summer and early fall due to the increased diversion rates during the rice irrigation season. It has been necessary to install the barriers almost every year since 1948 and the barriers, which are removed when they are no longer needed, have remained in place for as long as six months.

With the salt water barriers in place, the Neches River essentially becomes a dead-end navigation and waste disposal channel. The flow below the barriers results from treated industrial and municipal effluent return flows, very limited fresh water inflow from a small drainage area, and from tidal action.

Middle North Platte River Basin (ASR 1007)

Conflict Between Fish Habitat and Recreation Uses and Irrigation and Power Production Uses

This drainage area in southeastern Wyoming has major problems regarding instream flows which include basically insufficient streamflow, the inadequacy of minimum pools in storage reservoirs, and practices that dewater reaches of basin streams. These deficiencies adversely affect fish habitat and recreational uses of the waters.

With one exception, instream flow problems are more acute on tributary streams than on the North Platte River itself. Many streams are regularly dewatered during the irrigation season and flows are so erratic that they provide no fishery. Tributary reservoirs are also subject to severe fluctuations in pool level because of seasonal inflows and drawdowns. The large main stem lakes can usually withstand greater variances while maintaining some fish habitat and recreation surface.

The one instance in which practices on the main stem North Platte system do pose a serious instream flow problem occurs at Guernsey Reservoir. Guernsey, the farthest downstream reservoir in Wyoming, is annually drawn down rapidly to flush sediment. This practice is detrimental to the fishing in two ways: The North Platte River fishery is degraded by the heavy sediment load and Guernsey Reservoir is drawn down nearly empty, necessitating extremely low winter releases to fill it for the next season's irrigation needs.

Chowan and Lower Roanoke Rivers (ASR 301)

Conflict Between Potential Intrabasin Users and Present Interbasin Users

This problem area is located in extreme southeastern Virginia and eastern North Carolina in the Coastal Plain Province. The Nottaway and Blackwater tributaries of the Chowan River are present sources of 40 mgd (50 mgd maximum) of water for southeastern Virginia which is located in the neighboring Mid-Atlantic Region. Surface water demands on these rivers are expected to exceed safe yields by 1980. The projected source of supply for additional needs of 40 mgd is the Chowan or Roanoke River Basin, the latter being the most likely source. The point of diversion from the Roanoke River would be one or two hydropower projects, Roakone Rapids Lake or Lake Gaston. The problem in the South Atlantic-Gulf Region is that interbasin transfers now occurring from the Chowan River Basin and potentially from the Roanoke River Basin reduce flows available for downstream users and aggravate water quality problems.

Increased water supply needs within the Chowan River Basin can possibly be met without difficulty if there are no new interbasin transfers.

The effect of not solving this projected water transfer problem is that water would not be available for generation of hydroelectric power at both Gaston and Roanoke Rapids Dams in the Roanoke Basin. Water would also not be available for downstream industrial and fisheries resource users.

Snake River (ASRs 1703 and 1704)

Conflict Between Out-of-Stream and Instream Uses

The Snake River flows from eastern Wyoming, through Idaho, to Oregon and Washington where it joins the Columbia River. Any increase in withdrawals for irrigation and other consumptive uses will reduce flows in the Middle and Lower Snake River, thereby curtailing energy production at power dams in those reaches of the river. Expansion of irrigation, in addition to causing a reduction in energy produced at power dams, will also add to the energy load for pumping. The resulting difference between capability and load will have to be made up from alternative sources, principally thermal. The economic value of energy lost will increase as the cost of alternative sources of energy increases. The economic effect of the energy loss would thus be significant.

The only free-flowing reach of the Middle Snake River provides habitat for important resident and anadromous fish species and offers outstanding scenic and recreational values. As a recently designated wild and scenic river, it has national and regional importance. Excessive reduction in streamflow would detract from its attributes as a wild river as well as impairing the fishery habitat.

Passaic and Raritan Rivers and Northern New Jersey (ASR 202)

Insufficient Water Supply Projected

Future Consumption

The water supply situation in the near term is critical in this area for virtually all users, municipal, self-supplied industrial, agricultural, recreational, and environmental. In the Passaic and Hackensack river basins, surface supplies are approaching optimum development. Intra-regional development (Raritan River) will be required in the near term to service the 5 million people and the bulk of New Jersey's industries. Emergency planning for water supply crises due to system breakdown or drought conditions is presently inadequate.

Wabash River Basin (ASR 506)

Insufficient Water Supply Projected

Future Consumption

The Wabash River Basin includes most of Indiana, central Illinois, and a small part of western Ohio. Twenty-three communities in the basin are expected to have water supply service problems by 1980. Another potential water supply problem is that of electric power generation. If coal conversion plants were sited in the basin, they would pose a serious consumptive water use problem. Therefore, water supply must be considered one of the major problems in this basin.

Little Tennessee-Hiwassee (ASR 601)

Conflict Between Potential Recreation and Power Production and Flood Control

This problem area is located in the extreme southwest corner of North Carolina, the southeast corner of Tennessee, and along the mid-northern border of Georgia. There will continue to be a major loss of recreational user days at the Tennessee Valley Authority reservoirs. With optimum pool levels, recreational use would ultimately double in certain reservoirs over what it will be if current operating procedures continue as they are at present.

Major changes in the present operation of the reservoirs to enhance recreation would have a serious impact on the hydroelectric power generation of the TVA-ALCOA projects. Recent inhouse studies by TVA indicated that for 1975 observed flows and temperature conditions, maintaining high summer levels in all storage reservoirs would have vastly increased power generation costs. No allocation was readily available to the units in the Little Tennessee-Hiwassee problem area, but the costs there alone would be substantial.

Losses in power production would occur in three areas. First, maintaining higher summer level and modifying the releases would restrict the generation during the peak summer period when hydro generation is most valuable and would increase hydro generation during the fall and spring when load demands are not as high and hydro generation is therefore not as valuable. Second, the lack of generating capability in the summer would reduce the effective capacity of these projects and require that alternate capacity be obtained. Third, the reservoirs would be at high levels at the end of the summer recreation period and would have to be drawn rapidly to reach the flood control levels desired during the winter. In many years this would require increased spilling of water which would waste a natural resource. At present, these losses in power generation would have to be made up by increased use of coal and oil reserves which ultimately will impact the people of all areas as these natural resources are depleted.

Options for Resolution

The technical resolution of inadequate water supply problems is straight forward. They consist of two classes of actions: (1) increases in the available supply and (2) reductions the present or projected demand. Techniques to increase supply include developing new sources, increasing the recycling or reuse of existing supply and increasing efficiency in its distribution and consumption. Techniques to reduce demand include increases in price to consumers, institution of a conservation program to reduce use or eliminate waste, and changes in the institutional structures to increase efficiency of use.

There are no panaceas. Supply is essentially fixed but highly variable in specific locations. Demand continues to increase particularly in the more arid regions of the Nation. Depending on the location, conflicts are intensifying among in-stream and out-of-stream uses. The mechanisms to allocate the supply include state water laws; Federal laws, subsidies, and practices; treaties; interstate compacts; state utility commissions; and other public and private institutions. The present institutional arrangements are cumbersome and inflexible. Increased litigation and legislative initiatives are expected. It is obvious that more flexible allocation mechanisms are needed. An important short-run step to reduce conflict is increased efficiency and conservation which will provide water for additional uses from existing supplies. However, in the long run, more flexible allocation mechanisms are needed. The price of water to consumers plays practically no role in allocating water among uses. The use of water pricing and water permits to allocate supplies in many areas of the Nation is expected to be required.

GROUND WATER DEPLETION

Problem Definition

The ground waters of the United States are a vast resource estimated to have a volume far greater than all the surface waters, more than the total capacity of all the Nation's lakes and reservoirs (including the Great Lakes). The volume is equivalent to about 35 years of surface runoff. Yet increasing localized demands upon this resource cause mounting stress on the resource (Figure II-2).

Diminishing artesian pressure, declining spring and streamflow, land subsidence and salt water intrusion problems are strong evidence of excessive use of ground waters. Although the amount of water in storage is an extremely important factor, use of that water at rates exceeding natural recharge (i.e., mining) merely defers the inevitable day when (1) alternative sources must be found, or (2) serious decisions must be made concerning the continued existence of water dependent industries, irrigation developments, and proposed community expansions. In some areas declining water tables will cause abandonment of activities before the water is totally consumed because of the increasing cost of the energy to bring it to the surface.

Probably the most dramatic instance of ground water depletions are found in the Trans-Pecos areas of Texas. Severe and continuous declines in this area are the result of decades of pumping for irrigation and, more recently, from withdrawals for homes and industries. Abandonment

Ground Water Depletion

Legend

Areas with Greatest Total Impact
Areas that have groundwater depletion.

Location of Specific Impacts
● Mining of groundwater that exhausts the water source.
♦ Withdrawal that diminishes spring and stream flow.
▲ Withdrawal that causes subsidence and fissures.
■ Withdrawal that causes salt water intrusion into fresh water aquifers.

Figure II-2

of large acreages of irrigated areas began recently when the required high pumping lifts combined with sharp increases in prices for natural gas used to run the pumps resulted in uneconomic conditions for continued production.

Less dramatic, but prevalent throughout the Nation are problems facing municipalities that draw water from aquifers. Because ground waters have traditionally been assumed to be relatively inexpensive sources of unpolluted water of generally uniform temperature, cities, given an option, have chosen those waters rather than surface supplies. As population has increased, so have pumping rates and the number of wells. Some cities have found themselves forced to go deeper into aquifers of diminishing volume. As a consequence, forecasts indicate that many will face serious water supply problems by the turn of the century. If present use patterns continue alternative water supplies will be required; probably at much higher cost per unit.

The interconnection between surface and ground waters is commonly misunderstood, except perhaps where springs or smaller streams suddenly begin to go dry in the summer. Low flows in many larger streams (the base flow) is often mostly ground water that has returned to the surface. The interconnections may not be obvious; often the surface water drainage patterns have little or no apparent relationship to the ground water drainages. This is particularly true of larger ground water systems. Thus, excessive use of ground water in one area may result in surface water depletions in another; the benefit in one area may be a cost to another.

Where large amounts of water are removed from a ground water reservoir (whether or not mining is taking place) and the water level is lowered substantially, land subsidence may follow. In such situations the elevation of the ground surface may drop several feet over a relatively large area. Low-lying coastal areas have found increasing difficulty because of periodic flooding by higher tides in areas that previously were above tidal effects. Subsidence can also cause problems for structures in the area. Fissures (cracks in the ground) caused by dewatering have caused structural and pollution problems. Buildings have been damaged, highways and railroads have developed alignment problems, and fissures have allowed the direct entry of polluted surface waters.

On the Nation's coastal areas, many aquifers discharge below the adjacent salt waters. In the island areas, freshwater "lenses" actually "float" on the more dense salt water. Even in the interior U.S., pockets of saline water sometimes underlie, and are connected to, the fresh waters. Overpumping in such areas will cause the saline waters to migrate toward the wells. Given sufficient pumping pressures and time, the value of the wells as fresh water supply sources are reduced. In such situations, larger wells may cause problems for many smaller wells which by themselves would have been in balance with recharge rates.

Overpumping and consequent depletion also allows low quality near-surface waters to migrate into more protected lower aquifers. Careless handling of waste waters at the ground level also causes pollution of ground waters. Natural movement of water in aquifers is typically slow. Thus whereas a contaminated surface reservoir may be flushed out and be usable within a relatively short time, ground water reservoirs, once polluted, may take years to become safe water supply sources.

As with surface water systems, ground water aquifers are no respecters of political boundaries. Although water rights legislation in most areas covers ground waters, the same institutional problems of managing surface waters that cross state or national boundaries exist for ground water management.

Another serious problem of ground water management is lack of information regarding the extent, volume, recharge rate, and effect of various pumping schemes. Too often wells are dug, pumping begun, and problems of ground water depletion realized only when ground water levels begin to fall. Greater complications ensue when there are many wells. The use of sophisticated modelling capabilities to simulate regionwide ground water systems is possible. Without better capability to predict the consequences of ground water pumping programs, the beneficial value of the conjunctive use of surface and ground waters cannot be planned effectively.

Implications

Those areas essentially dependent on ground water sources as an economic base may require special consideration from a national perspective. For example, the High Plains of West Texas and Eastern New Mexico contain the largest irrigable land mass in the world -- 52 million acres or a land mass larger than 37 of the States of the United States. Nearly 10 million presently irrigated acres overlying the Ogallala aquifer are threatened. The loss of this area to agricultural production would be of significant national importance. Because local surface water sources are inadequate, large importations are being considered to save this valuable resource.

In the absence of an alternative source of water supply, some irrigated lands now dependent upon ground water mining will revert to dry land production. On-farm income and production will be reduced, and ultimately the size of the farms will have to be increased in order to make operations economical.

Overpumping of ground water will have environmental consequences. Base flows in streams will be reduced or eliminated, resulting in increased harm during critical low-flow periods to aquatic and wildlife habitats in streams, wetlands, coastal marshes, and estuaries. Often the precise location of a possible threat cannot be related to specific ground water pumping locations.

Although ground water depletion may have divergent causes and have a variety of adverse effects, the demand for ground water and the diminishing supply seem certain to continue under current projections. While ground water may in many areas continue to meet much of the increasing need in the short term, state governments, perhaps with the assistance of the Federal Government, will inevitably be forced to bring rates of withdrawal into balance with rates of recharge to ensure the availability and fullest use of fresh ground water supplies. Unless plans are made in advance, those resources may be insufficient or unavailable when needed. More frequently, joint use planning may recommend extended ground water use for irrigation, in normally humid areas, during short-term seasonal droughts.

Specific Problems

The following representative specific problems illustrate the distribution and variety of problems. The information was furnished by Regional Sponsors.

Gila River Basin (ASR 1503)

Overdraft of Ground Water for Irrigation and Other Uses Causes Subsidence and Other Problems

The water supply of the Gila River Basin in the southern two-thirds of Arizona and eastern New Mexico has been developed and utilized for many decades. Except for infrequent large floods or an exceptional runoff sequence, outflow from the basin under present conditions of development is negligible. Further development of surface water within the basin is confined principally to the conservation of a portion of these waters which may become outflow, measures to increase runoff, and the reduction of noncrop consumptive use associated with irrigation and other uses. The expanding economy of the area has been supported by an overdraft of ground water and current ground water pumpage exceeds surface water diversion by several times.

Water depletions are expected to remain at about 4.1 million acre-feet annually through 1985. Increased depletion for municipal, industrial, mineral development, and thermal electric powerplant cooling are expected to be balanced by a decrease in irrigated agriculture of about 68,000 acres. The depletion of ground water reserves would total about 25 million acre-feet over the 10-year period.

In 1990, the Central Arizona Project is expected to convey 1.4 million acre-feet to the area which would reduce ground water overdraft by about 60 percent. However, by 2000 increased water use would exert renewed pressure on the ground water resource.

At some time in the future it will be necessary to balance water supply and use. If not through legislation, it will probably occur through economic pressures as increased pumping depletes water supplies and energy rates reach a level where irrigated agriculture is no longer profitable. If water use and supply were to reach a balance by year 2020 in those counties where there is adequate irrigated agriculture to achieve this, there would need to be a reduction of over 600,000 irrigated acres, or about 63 percent of the land area irrigated in 1975.

Declining ground water levels present a number of problems. In 1970, the total ground water pumped in the basin above Gila Bend, Arizona, was 4.3 million acre-feet. For each foot of increased pumping head an equivalent of about six million kilowatt hours of electric energy is required. Land subsidence results in some areas as ground water aquifers are dewatered. The best documented case is in western Pinal County and areas of Lower Santa Cruz Basin where the maximum subsidence measured was 7.5 feet near Eloy for the period 1948-1967. Earth fissures as much as eight miles long occur along the edge of the area. Subsidence has damaged Picacho Reservoir, water wells, railroads, streams, highways, and agricultural land.

High Plains (ASRs 1010 and 1103)

Overdraft of Ground Water for Irrigation Results in Dropping Water Table

The plateau formed by the Ogallala formation gives shape and definition to the High Plains portions of Nebraska, Colorado, Kansas, Oklahoma, New Mexico, and Texas. Because of its mantle of rich and relatively level topsoils, the Ogallala formation has given rise to one of the largest, if not the largest, irrigated agriculture developments in the world.

The important distinguishing characteristics of the Ogallala area in Kansas are its vast yet declining ground water supply, its tremendous irrigation developments, and the relative certainty that these irrigation developments will eventually be adversely affected by the declining ground water supply.

San Joaquin Valley (ASR 1803)

The San Joaquin Valley has the largest ground water overdraft of any area in California. While the annual overdraft has declined from its peak days in the mid-1950s during corresponding normal years of comparison, present data indicate about 1.5 million acre-feet per year of overdraft is, on average, still occurring. This ground water overdraft results in increased pumping costs, threat of quality degradation at scattered locations, and land subsidence in others.

If overdraft continues, at some future date, land supported by overdraft will be forced out of production because of quality degradation and/or excessive pumping lifts.

Upper Susquehanna River Basin (ASR 204)

Conflict Between Municipalities Over Ground Water

This problem area includes the drainage into the Susquehanna above Towanda, Pennsylvania. In the near term there are generally low ground water yields in areas with increasing demand. There is a significant need to determine the relationship between surface and ground water, such as the lag time between pumping and base flow depletion. There could probably be further development of ground water sources if relationships were more specifically determined, especially in and around Elmira, New York. Withdrawals of ground water for municipal and industrial needs of Elmira and for irrigation in the area exceed recharge and pose a threat to both surface and ground water supplies. Protection of recharge areas and management of withdrawals are required in the Upper Camisteo and Cohocton River Valleys and in the Cortland and Binghampton urban areas.

Southeast Georgia (ASR 303)

Withdrawals of Ground Water For Development and Resulting Saltwater Intrusion

Under present rates of pumping, ground water quality is threatened in the Savannah area and salt water intrusion is beginning to occur in in the Brunswick area. Ground water withdrawals, expected to double between 1970 and 2000, would greatly accelerate salt water intrusion under existing conditions. The quality of water and high costs to develop new sources make it almost prohibitive to use surface sources for domestic water supplies.

The degradation of ground water quality are expected to force industries to change their pumping systems to handle more corrosive water, develop more expensive (four to five times the cost of ground water) surface water sources, and/or develop ground water sources outside the problem area. Present water management methods have restricted development in prime industrial areas adjacent to Brunswick. This restricted development could result in local loss of millions of dollars annually.

Some small domestic and industrial users of these aquifers do not have access to public water systems and they will have to install costly wells to tap deeper uncontaminated aquifers. This will aggravate the problem of salt water encroachment in the lower aquifers.

Houston-Galveston Area (ASR 1202)

Ground Water Overdraft Causes Subsidence

Pumping of ground water in the Houston-Galveston region has steadily increased in recent years. As a result, artesian pressures have declined and subsidence has accelerated. A recent study found that annual costs and property value losses totaled an estimated $31.7 million per year in the area. These costs were borne primarily by residential, commercial, and industrial property owners. However, over $500,000 per year in costs were included for damages and repairs to public facilities.

Overdrafting of ground water aquifers, which results in subsidence, also leads to salt water encroachment and damage to the affected water aquifers. Some low-lying areas along Galveston Bay are subject to inundation by normal tides, and an even larger part of the region may be subject to catastrophic flooding by hurricane tides. Surface drainage has become less effective and in some cases drainage patterns have been reversed as a result of subsidence.

Subsidence is expected to continue at a rate dependent on the decline in pressure resulting from future ground water pumping. However, surface water from the adjacent Trinity River Basin and Brazos River is now being delivered and is available for major ground water users in the southern part of Harris County--the heart of the subsidence zone. The switch from ground water to surface water has already resulted in some recovery of artesian pressure and has thereby decreased the rate of subsidence. However, additional surface water supplies must be developed to replace ground water to further reduce the effects of subsidence.

Overdraft in the analytic problem area supports approximately 600,000 acres of crops. The gross production value for this amount of land approximates $300 million in 1967 dollars based on 1974 marketplace conditions.

State economic impact as the result of lost productivity of 600,000 acres would be perhaps $1.2 billion based on the 4:1 generating ratio of other activities to gross farm income.

Oahu (ASR 2003)

Potential Development May Damage Aquifer

On this most highly populated of the Hawaiian Islands, highly permeable soils and rocks permit much of the rainfall to infiltrate to ground water supply. These sources of ground water are lenses of fresh water floating on intruded sea water; the quality of the water in these lenses is very high. The fresh water-salt water balance in the lens is sensitive and the withdrawal of fresh water must be carefully controlled to prevent deterioration in quality by salt water intrusion.

Pumping from ground water supplies is currently within safe yield limits. Overdraft is foreseeable in the Pearl Harbor aquifer on the Island of Oahu if additional water development facilities are constructed without compensating conservation measures. Voluntary controls by the water users on Oahu are being attempted to prevent overdraft in the Pearl Harbor aquifer. The State Department of Land and Natural Resources is ready to implement a ground water management program should voluntary controls fail.

Options for Resolution

In some areas of the Nation, particularly in those of intense irrigated agriculture, the water supply situation makes it inevitable that economic and social dislocations will occur. In those areas agricultural production is based on ground water mining which cannot be sustained indefinately. One option is to do nothing--to allow the economic and social factors to adjust themselves. The result is likely to be the return of large acreages of presently irrigated cropland to dryland farming or ranching, with some reductions in food and fiber output, vast social readjustment, population redistribution, and a major business/economic restructuring to reflect the area's changing conditions. However, this also occurred when irrigated agriculture replaced rainfall based agriculture.

At the other end of the possible options to protect against potentially major social and economic counsequences is for alternative sources of water supply to be found, transferred, and used. Major, and extremely costly, interbasin and intercontinental diversions of excess waters have been suggested. In reviewing surface water supply conditions of the Nation it is not apparent that there are regions with significant amounts of truly excess water supplies to be transferred to the Texas High Plains and other ground water mining areas. However, smaller interbasin diversions probably could be accommodated. Larger transfers would probably involve interstate and international boundaries and potentially could lead to more intense interregional conflicts.

The most important first step will be the development of institutional mechanisms to increase flexibility in the use of ground waters. Also mechanisms which would permit ground and surface waters to be conjunctively managed are imperative. Use of the tremendous volumes of the Nation's aquifers potentially offer the capability of supplementing surface supplies during periods of drought. The artificial recharge of aquifers during periods of surplus surface runoff could increase the volume available. This may require national programs of technical and financial assistance.

Those states not now adequately controlling ground waters should be provided incentives. A program of ground water withdrawal permits could reduce consumption and provide the basis for improved management. Additionally, more studies should be started to analyze the social, economic, and environmental costs of the failure to plan adequately for the use of the Nation's ground waters. With this information, programs to guide and encourage the states in the management of their water resources could be more properly designed.

SURFACE WATER POLLUTION

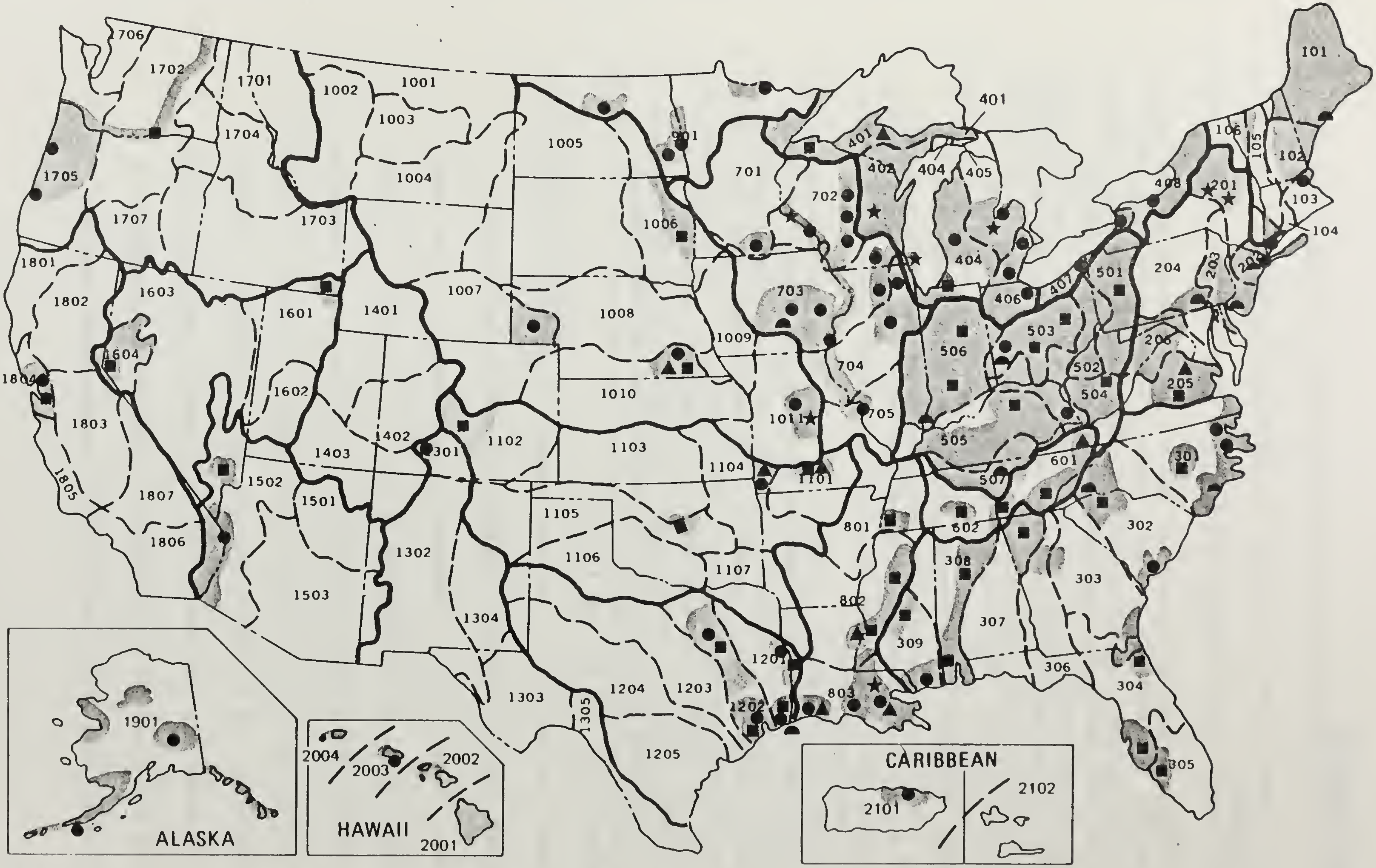
Problem Definition

Historically, the Nation's streams, rivers, lakes, and oceans have been convenient, and seemingly inexpensive and inexhaustible, dumping areas for human and animal wastes and residuals from industrial production. All this, in spite of the fact that a majority of the population has always depended, directly or indirectly, on these same streams, rivers, and lakes for much of its fresh water supplies, water-related recreational activities and aesthetic beauty.

The Nation's growth was based upon an abundance of natural resources. Communities were initially self dependent. The underlying interconnection of institutions and natural systems was not recognized, let alone understood. To varying degrees, we now realize that we have created a problem (Figures II-3a, II-3b, and II-3c).

The growing realization of the environmental degradation the Nation has led progressively to stringent legislative efforts to cope with these problems. These efforts culminated in the passage of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500). Efforts to clean up and prevent further degradation of surface water resources have received priority attention by Federal, State, and local officials and private entities. As a result, the quality of the surface waters near some urban areas has improved. In other areas widespread surface water pollution still occurs as a result of point source discharge of municipal and industrial wastes and non-point source contributions.

Surface Water Pollution from Dense Population or Industry



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Areas with Greatest Total Impact

Areas that have serious degradation of water quality.

Location of Specific Impacts

● Municipal, industrial, and/or feedlot coliform.

★ PCB, PBB, PYC, and related industrial chemicals.

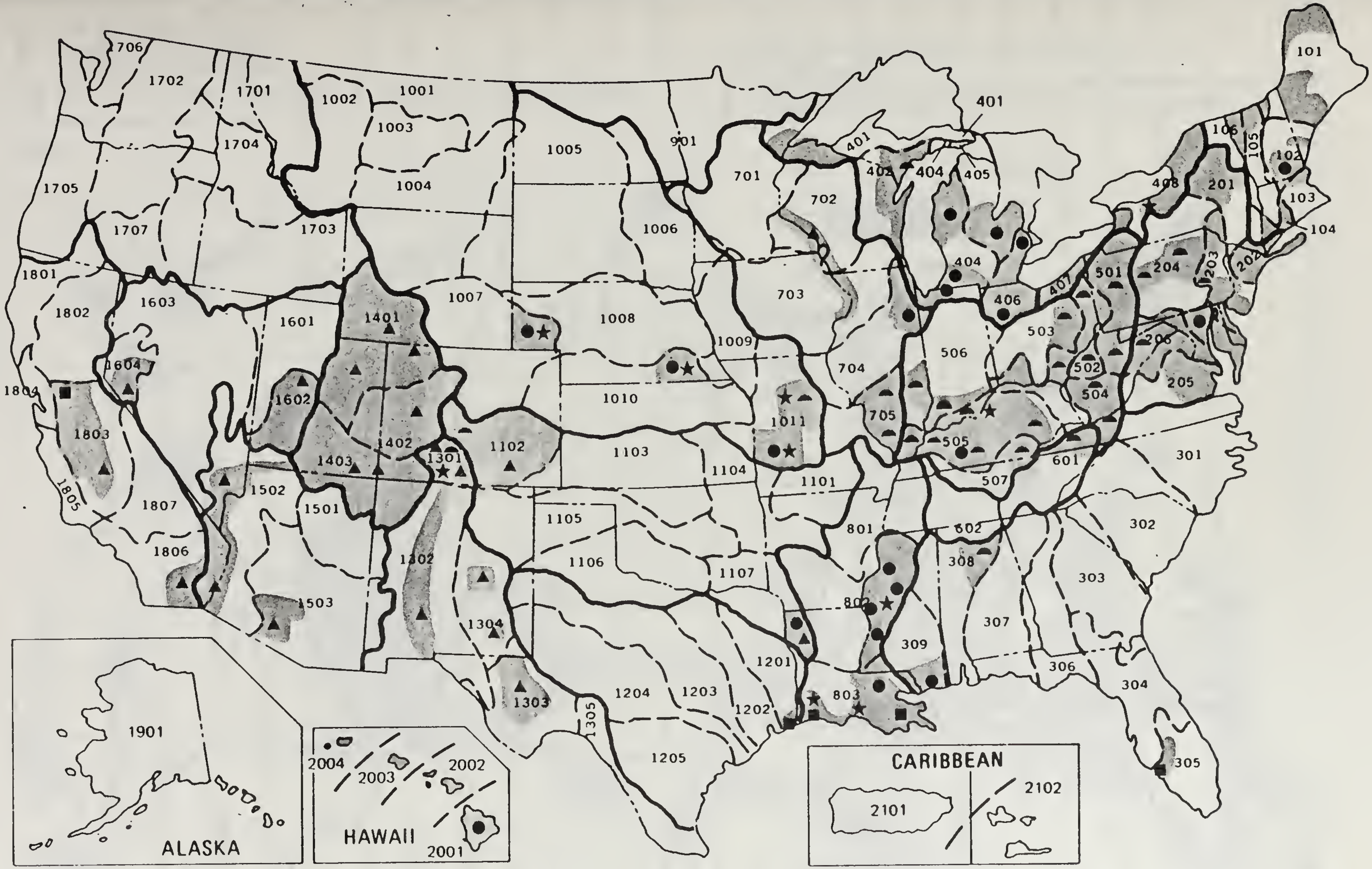
▲ Heavy metals and other toxic chemicals.

■ Concentration of general pollutants (such as nutrients) from municipal and industrial discharges.

◓ Heat from manufacturing and power generation.

Figure II-3a

Surface Water Pollution from Dispersed Sources



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Areas with Greatest Total Impact

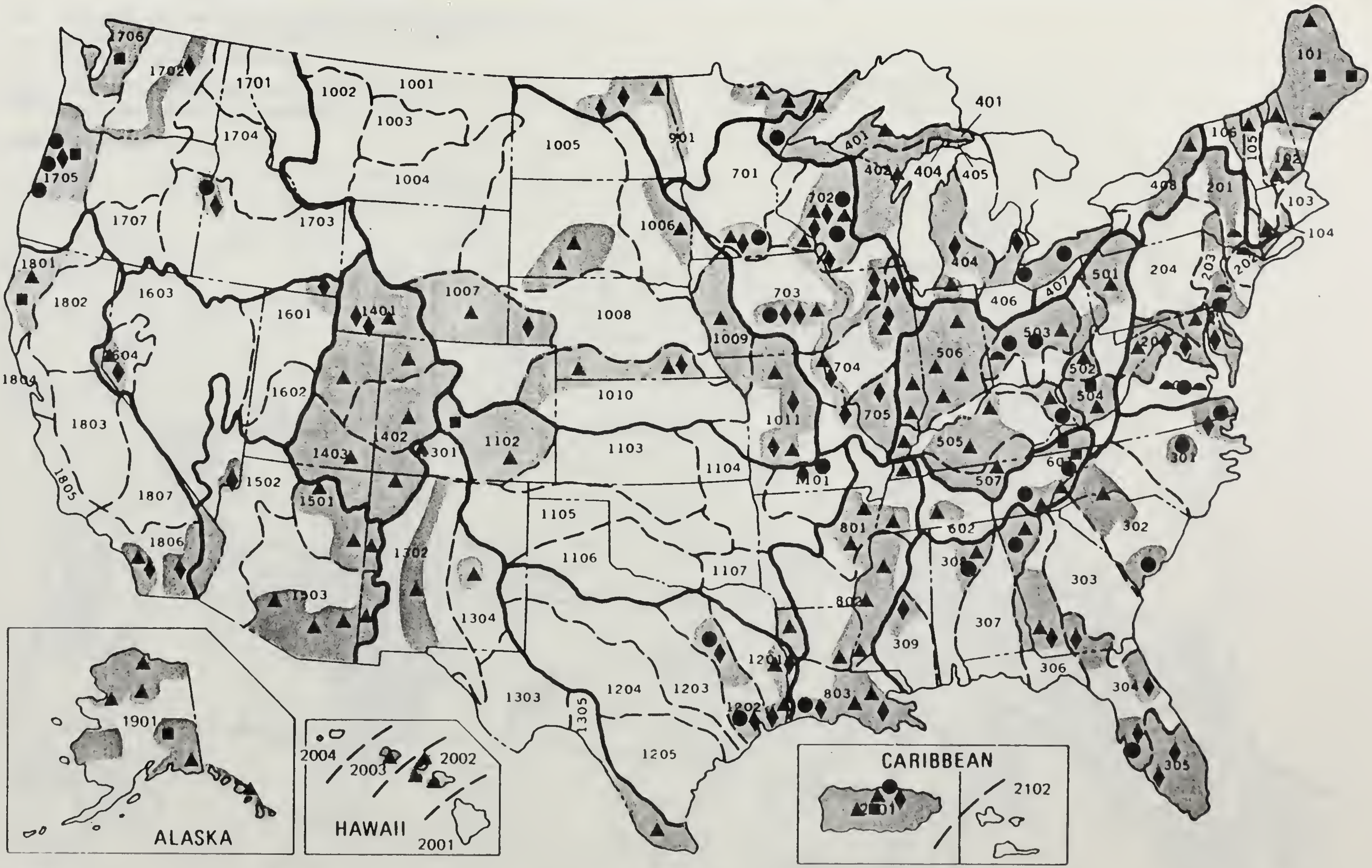
(shaded) Areas that have degraded water quality from dispersed sources.

Location of Specific Impacts

- ● Herbicides, pesticides, and other agricultural chemicals.
- ★ Undesirable concentrations of agricultural chemicals (fertilizers, etc.).
- ▲ Salinity from irrigation return flows.
- ■ Coastal surface saline intrusion.
- ◓ Mine drainage.

Figure II-3b

Surface Water Pollution Eutrophication of Water Bodies



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Areas with Greatest Total Impact

Areas that have serious eutrophication of man-made and natural water bodies.

Location of Specific Impacts

● Low dissolved oxygen levels.

♦ High concentration of nutrients.

▲ Sedimentation from stream bank, cropland, and natural erosion.

■ Man-induced sedimentation from urban, industrial, and construction/earth moving activities.

◓ Heat from manufacturing and power generation.

Figure II-3c

Surface Water Degradation From Point Sources

Point sources of surface water degradation are defined as those where specific discharge from an identifiable entity can be pin-pointed. These sources are generally associated with the discharge of municipal and industrial wastes. A minimum of secondary treatment for municipal wastes and best practicable treatment for industrial discharges is currently required by the Water Pollution Control Act. Current treatment practice for municipal wastes ranges widely. There are instances of untreated municipal wastes, many examples of only primary treatment, and additional cases where the secondary treatment provided is insufficient to maintain water quality standards.

Industrial discharges range from those that are compatible with municipal wastes and conventional waste treatment techniques to those requiring specialized techniques for treatment before safe discharge. Treatment techniques often lag behind product development, and resultant discharges can have adverse environmental effects. Existing environmental insults persist from prior discharge of polychlorinated biphenyl (PCB) laced discharges. Discharges of waste metal plating liquids to municipal treatment plants have resulted in plant malfunctions.

These various discharges contribute oxygen demanding substances, nutrients, a variety of toxics and fecal coliforms. The presence of fecal coliforms in water supplies is indicative of the possible presence of disease-causing organisms, including those responsible for typhoid fever, paratyphoid fever, dysentery, and cholera. The linkage of water supply and water borne waste disposal systems in some populated areas means that any malfunction in either system could result in disease outbreak or other adverse health effects.

With the increase in industrial and municipal waste treatment plants, municipal and industrial wastes are projected to be under control before year 2000. However, since chlorine, the disinfectant of choice, is used by most waste and water supply treatment plants, new health problems may be introduced even while others are resolved. Harmful chlorinated hydrocarbons, including carcinogenic chloroform, can be produced in both water supply and waste treatment processes when chlorine is applied for purposes of disinfection. Chloroform can also be generated in streams when chlorinated discharges combine with significant amounts of humus found in stream beds.

Temperatures above the natural background temperature cause a greater decrease in the dissolved oxygen concentration than that which would otherwise occur. Temperature rises are associated with the discharge of cooling water from power generation and manufacturing processes and from some reservoir releases. Temperature fluctuations affect the natural environment and threaten the survival of many aquatic flora and fauna. With an anticipated 350 percent increase in waste heat from manufacturing and power operation by the year 2000, the natural environment may be severely stressed unless proper corrective actions are taken.

Surface Water Degradation From Dispersed Sources

In the past, little concern was given to the effects on surface water quality of pollutants carried into water bodies by runoff from dispersed sources. Provisions of the Water Pollution Control Act now focus attention on these non-point source problems. Areawide planning efforts have addressed this problem and an attempt has been made to develop methods for its abatement and control. Generalized areas of concern have been identified. In many cases interactions in these generalized areas have been established qualitatively but precise quantification has proven difficult.

Non-point sources of pollution include both man-managed sources and natural sources. Runoff from urbanized, agricultural, forested, and mining areas can be addressed in terms of management and abatement techniques. Naturally occurring non-point sources such as the salt flats in the southwest, which contribute high concentrations of total dissolved solids and salinity, and streambank erosion, are recognized as pollutant sources, but are more difficult to control although their impact on surface water quality is significant.

The containment or management of these diffuse sources of pollution is difficult. The precise relationship between the sources and the resulting water quality is not well understood. Pollutant concentrations tend to build up during periods of dry weather and are washed into streams during periods where precipitation is heavy enough to produce runoff. The total load of pollutants is a function of pollutant concentration build-up and the volume of runoff.

A majority of the States report agricultural activities as the primary source of sediments. Associated with sediments washed off the land surface are herbicides, insecticides, and undesirable levels of fertilizers and other nutrients that enter the streams. The National Residuals Discharge Inventory indicates that about 33 percent of the oxygen-demanding loads, 66 percent of the phosphorus, and 75 percent of the nitrogen discharged to the streams in 1973 comes from dispersed agricultural sources.

Silvicultural activities can also be a source of non-point source pollutant problems. Increased runoff caused by wholesale clear cutting of trees for lumber and related wood products by traditional logging operations can leave soils unprotected and highly scarred. Rapid erosion often ensues before tree cover and related vegetation can be reestablished. Under those conditions forest soils and their natural nutrients will erode, degrading both the soil's productivity and the quality of the streams and rivers receiving the eroded material.

Many states identify mining, primarily that associated with acid-mine drainage and sediments, as a major problem. In certain areas where deep or strip mining is or was prevalent, acid mine drainage contaminates both surface and ground water supplies. Abandoned mines compound the problem because no one will acknowledge responsibility for them. Consequently, prior mining activity continues to affect water quality.

Excess salinity is a serious water quality problem in several states in the West and Southwest. Irrigation water leaches salts from the soil, and salinity concentrations increase in the return flows to surface water courses. Each subsequent irrigation application tends to increase the salinity concentration to the point where plants are no longer tolerant of the concentrations. It has been estimated in the Lower Colorado River that for each milligram/liter increase in salinity the annual cost to the economy in reduced yield is approximately $230,000.

With increased consumptive use of the Nation's waters, less fresh water flows into the surrounding boundary salt waters. As a result, the dynamic balance at this fresh water/salt water interface is adversely affected. As the streamflow decreases, the saline water intrudes further upstream. A consequence of saline water movement is that intakes along these streams experience greater saline contents from previously freshwater sources. The user is thus faced with either using the degraded water or finding alternative, and more costly, sources. Intrusion of highly saline sea water up tidal estuaries has been identified as a problem in California, Florida, Louisiana, and Texas. The potential exists along all coastal areas.

Stormwater runoff and combined sewer overflows from urban areas are significant sources of sediment, nutrients, heavy metals, and biological contamination. The combined sewer overflow problem will continue to persist because of the high cost of correcting this plumbing mistake of the past. With increasing urbanization, the problems of stormwater runoff can be expected to intensify. The magnitude of potential for pollution from storm water runoff has only recently been investigated. In many areas, failure to solve the problem will leave a major source of pollution unchecked.

Eutrophication of Man-Made and Natural Water Bodies

Eutrophication, a natural process of aging of a water body that normally takes centuries, has accelerated in many places because of man's activities. In the eutrophication process aquatic plants proliferate when an abundance of nutrients is available. When aquatic plants become overabundant, dissolved oxygen levels are depleted in water bodies during nighttime or other periods when oxygen producing photosynthetic processes are dormant. The result of oxygen depletion is the death of aquatic plants and animals, with consequent decay and odor.

Dissolved oxygen levels in surface waters are also lowered by thermal discharges associated with the cooling water needs of manufacturing and power generation.

Eutrophication is hastened by the addition of nutrients to water bodies. The primary nutrients, carbon, nitrogen, and phosphorus, are essential to the growth of aquatic plants, and carbon compounds are ever present. Nitrogen and phosphorus are nutrients generally found in excess in domestic sewage, agricultural runoff and irrigation return flows, urban runoff, atmospheric fallout, septic field leachates, and certain industrial waste discharges. Nitrogen and phosphorus are commonly monitored and are the two nutrients most affected by human activities. Control of either nitrogen or phosphorus, whichever is critical in a particular instance, can delay eutrophication.

Implications

Poorly operated municipal plants discharge high counts of bacteria and viruses, among which are known pathogens. Industrial discharges, particularly of toxic chemical wastes, can make surface waters a health hazard for public use. Trace levels of PBBs, PCBs, heavy metals, asbestos fibers, and a variety of contaminants constitute some of the health hazards. In some cases substances, not carcinogenic in themselves, can combine with other substances to form carcinogens when discharged to water courses.

Urban runoff containing bacteria, residues of toxic substances, trace heavy metals, and accumulated urban debris are washed into surface water courses (and in some instances find their way into ground water supplies). Agricultural runoff may contain high concentrations of bacteria, excess insecticides and herbicides, and fertilizer in addition to relatively large quantities of sediment. Return flows from irrigated fields contain salts and minerals leached from the soil. These return flows have progressively higher concentrations of total dissolved solids with each successive application. Some of these substances are toxic in themselves; some are carcinogenic. All serve to further degrade surface waters.

Excessive supplies of nutrients--phosphorus and nitrogen, in particular--can cause algae and water hyacinths to flourish. These aquatic plants produce an abundance of dissolved oxygen when photosynthesis occurs. However, when photosynthesis is reduced by cloud cover, or ceases at night, oxygen uptake by these plants results in oxygen depletion and eventually death of aquatic fauna and flora. The resulting stagnant waters become breeding grounds for insects such as mosquitos, which are disease carriers. Anaerobic conditions associated with eutrophic waters encourage the growth of pathogenic organisms found in the dead carcasses of diseased fauna.

Oxygen consuming wastes from urban, industrial, and rural sources, together with low flow and higher surface temperatures, impair water quality. An abundance of nutrients, which encourage growth of aquatic plants, can cause streams and lakes to become choked with these plants and to become oxygen depleted. Many chemical wastes are soluble and easily dispersed in surface waters. Others precipitate and are transported with the stream bed load. Increased water withdrawals will tend to concentrate these pollutants to levels which cannot be tolerated. Some insecticides and herbicides will accumulate in the flesh of fish. The effects of these insecticides and herbicides may persist for years and be potentially hazardous to both aquatic animals and humans.

Bacteria and fecal coliforms, toxic chemicals, and a host of deleterious substances can render shellfish unsafe for consumption. When economic losses to those that provide recreational services and equipment occur.

Surface waters, once degraded, often require disproportionately higher costs for treatment to render them suitable for the higher water uses than the total cost required to treat, conserve, and preserve water at high quality after use. Those costs, furthermore, are unfairly transferred from the polluter to the downstream water user. The greater the quantity and type of pollutants in the water, the more complex and energy intensive will be the operations required to reduce contaminants and pollutants to the level appropriate to the use intended.

Water quality is already an issue between the U.S. and its neighbors. Further degradation can only aggravate the situation.

The control of point source discharges, as mandated by P.L. 92-500, is a pressing problem. As point sources are brought under control, the true impact of non-point sources will be realized. If both point and non-point sources can be brought under reasonable control, then the conditions that induce eutrophication of our lakes and slow-moving streams will have been checked. If not, continued deterioration of rivers, streams, and lakes will continue. The result will be excessive treatment costs and a threat to public health. Attendant losses will include finfish and shellfish resources, reduced crop yields, and loss of beauty in the environment.

Specific Problems

The following specific problems illustrate the distribution and variety of water pollution problems. They are not necessarily the most serious instances but are considered representative. The information was furnished by Regional Sponsors.

Mississippi River below Minneapolis-St. Paul, Minnesota (ASRs 701 and 702)

In the Mississippi River below Minneapolis-St. Paul there are localized point sources of pollution from municipal and industrial waste discharges at major urban centers, oil and chemical spills from barges and adjacent rail traffic, and sewage wastes from pleasure and work boats. The Mississippi

River is subject to high turbidity stems from erosion and natural runoff. Addionally, sewage is added from municipal and industrial sources. Significant non-point pollution problems also stem from agricultural land runoff resulting in high chemical and bacterial concentrations, nutrient levels, and lake eutrophication.

Two large lakes totaling 1050 acres in Grant County, Wisconsin are classified as 'very eutrophic'. Water quality problems are also associated with runoff from lead and zinc mines in southwestern Lafayette and southeastern Grant Counties in Wisconsin. Serious PCB contamination of fish habitat areas occurs in Lake Pepin. Some concern has been expressed about the deterioration of ground water quality in the fractured and cavernous limestone areas of southeastern Minnesota.

Tennessee River Basin (ASR 601)

Water quality in the North Fork Holston River is adversely affected by leachate from muck ponds at an abandoned chemical plant site in Saltville, Virginia. Runoff from heavy rains causes the muck ponds to overflow. Among the parameters which are impairing use of the river are dissolved solids (chlorides) greater than 500 mg/l and mercury. The mercury concentrations in the fish in the reach between Saltville, Virginia and Kingsport, Tennessee, exceed that allowed by the U.S. Food and Drug Administration. Although fishing is allowed, those taken are not supposed to be eaten, but there are indications that this warning is ignored.

Lake Okeechobee Area, Florida (ASR 305)

Agricultural runoff, urban runoff, and treated waste residuals contribute to degradation of water quality in the canal systems, coastal streams, and estuaries. The resulting nutrients are causing eutrophic conditions in lakes of the area, resulting in large accumulations of organic matter and aquatic weed growth. A significant area south of Lake Okeechobee has large amounts of irrigation return flow. Sanitary landfill drainage, thermal pollution, and septic tank effluents are also degrading water quality of surface waters, ground waters, and estuarine waters.

Options for Resolution

Point sources of waste water discharge may be effectively treated at point of discharge. The goals of the Federal Water Pollution Control Act of 1972 are in the process of being met. All point sources should have the equivalent of secondary treatment for municipal/domestic discharges or best practical treatment for industrial discharges by 1985. This goal is expected to be met uniformly throughout the country.

New technology is needed to effectively and inexpensively render industrial wastes harmless. Potential actions include incentives to industry to find suitable uses for industrial waste products. An example of such success is the product ethylene glycol, once a waste product of the chemical industry that is now the cornerstone of the antifreeze business.

Use of septic tanks and cesspools should be discouraged. However, alternatives to such private waste disposal practices are needed. Such treatment should provide a high degree of waste water treatment and minimize the localized impact of waste water discharges.

Techniques available to reduce non-point source pollution include street sweeping and catch-basin maintenance or similar alternatives. In most areas the separation of existing combined sewers into separate sanitary and storm sewers appears to be economically unfeasible. A potential action is the installation of combined sewer relief valves so that each rain storm does not result in a combined sewer overflow. Further, the option of construction of detention tanks should be strongly investigated.

Greater use of soil conservation and streambank stabilization practices in agricultural and construction areas will reduce pollution. The use of modern cropping and tillage practices by farmers will reduce soil losses from their lands. Better methods are needed to prevent the overapplication of herbicides and pesticides. Incentives are needed to increase use of detention ponds to minimize storm runoff from urban areas and settling ponds for irrigation return flow.

Concurrent with the implementation of waste water and non-point source policies and technologies, more effective water treatment practices are needed. This will require increased research into improving present treatment practices and devising new treatment options. Toxic substances and carcinogens are already found in some water supplies. Expanded research into measurement, sources, and effects on human health is needed to establish safe levels for trace contaminates.

GROUND WATER CONTAMINATION

Problem Definition

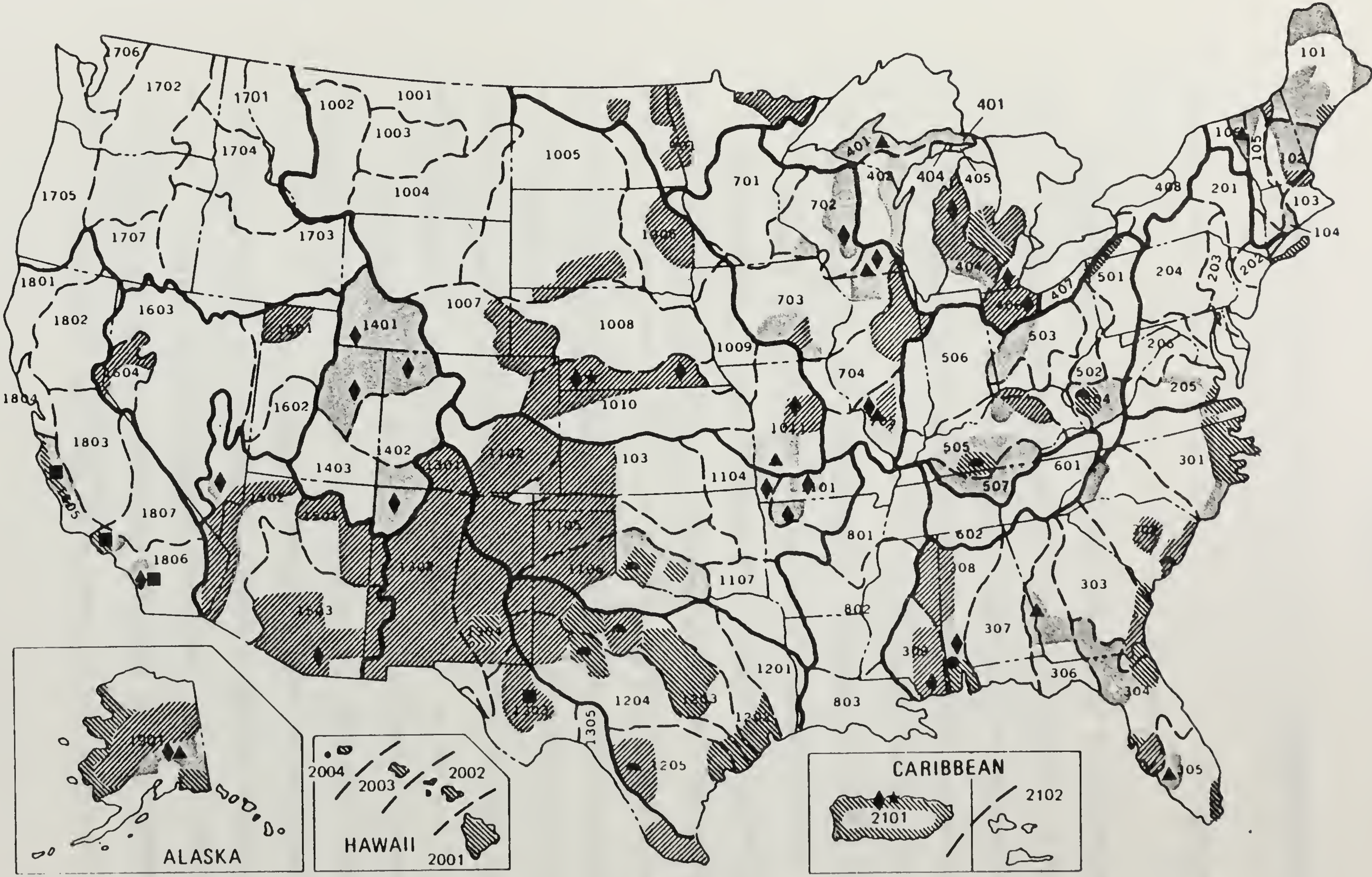
The contamination of underground water sources is a growing issue across the Nation. Because aquifers lie below the surface, out of sight, the seriousness of ground water pollution is only gradually being realized. Most regions reported some form of ground water contamination in the Second Assessment (Figure II-4).

Ground water is a key component of the Nation's water supply. Over 50 percent of the U.S. community water systems and individual supplies are now dependent upon ground water as a source. About one-third of the country has ground water reservoirs generally capable of yielding at least 50 gallons a minute to a well.

People have come to expect safe water to be produced from wells because of the natural filtering action of the soil through which the water must pass. However, ground water supplies have been contaminated from a variety of sources and both natural and man-induced contamination affect the resources. Once contaminated, the ground water essentially becomes a resource of limited use. Ground water is not as easily restored to a healthful condition as surface water when contaminated.

Natural pollution includes the high mineralization of ground water from excessive levels of such chemicals as magnesium, iron, sulfur, nitrates, phosphorus, calcium, fluoride, and brine. In addition, natural radioactivity may pollute certain ground water supplies. Instances of

Ground Water Contamination



Legend

Areas with Greatest Total Impact

- Areas that have ground water contamination.
- Areas with saline water intrusion (actual or potential) or natural salinity.
- Areas with high levels of minerals or dissolved solids in ground water.

Location of Specific Impacts

- ● Contamination resulting from leaching of municipal and industrial wastes and waste runoff through oil and gas fields and other excavations.
- ♦ Contamination resulting from toxic industrial wastes.
- ▲ Contamination resulting from leaching of wastes from land fills.
- ■ Salt and other chemical contamination of aquifers from irrigation and other agricultural activities.
- ◓ Inadvertent contamination from well drilling, harbor dredging, and excavation for drainage systems.
- ★ Contamination from deep well injection.
- √ Natural radioactivity in ground water.

Figure II-4

radioactivity have been found in such diverse States as Florida, Maine, New York, Illinois, Iowa, and Missouri. Natural pollution may not always render ground water supplies totally unusable, but certainly makes them less desirable. The drilling of oil and gas wells has resulted in cases of the intrusion of brine into otherwise high quality ground waters making them undesirable for use. Additionally drilling has caused the pollution of aquifers by oil and gas. The overdrawing of ground water supplies in coastal areas has resulted in contamination from salt water intrusion.

In a few communities scattered across the country, serious incidents involving deep-well injection of toxic and hazardous wastes have distributed contaminants throughout important aquifers. Through these locally contaminated aquifers, much broader areas have been adversely affected, and some users have experienced interruption in water service.

Seepage from landfills containing municipal and industrial wastes also adversely affects ground water quality. In the past, known highly toxic substances have been buried indiscriminately in landfills or dumps. In some areas the location of such dumps that have been abandoned is unknown and so is the extent of their effects on surface and ground waters. In general, the adverse effects of solid waste landfills are greatest in areas with large concentrations of population and industry.

In rural areas, agricultural irrigation leaches salts into ground water bodies, representing yet another source of potential contamination. Contaminants and pollutants that may result from herbicides, insecticides, and fertilizers can also infiltrate the ground water.

Subsurface percolation systems such as septic tanks and cesspools are a further source of ground water contamination. Urbanization of previously rural and suburban areas has resulted in concentrated population in areas where centralized water and sewage facilities are lacking. The widespread use of these waste water disposal systems has led to fecal contamination of adjacent aquifers. Instances of such local aquifer contamination are found throughout the Nation. In some areas, such contamination has been compounded by the proximity of oil and gas wells, dry wells, sink holes, and coal mines.

Ground water recharge occurs from surface streams and water bodies. Contamination of surface waters will ultimately impair ground water supplies, especially in areas where recharge is significant. Conversely, surface waters may be polluted when base flow is provided by polluted ground waters. The linkage between surface and ground waters is physically complex. Because ground water aquifers often extend across the boundaries of different States, counties, and local jurisdictions, concerted study and careful management is often complicated because of legal and political constraints.

Implications

Ground water pollution, in one form or another, is recognized in most of the regions. Most often identified are high levels of mineralization in the ground water aquifers. Contamination, or potential contamination, of ground water aquifers by fecal coliforms from septic tank drain field failures is an often cited problem in the rural areas. Industrial, municipal, and agricultural wastes are degrading or contaminating valuable ground water aquifers, or have the potential for doing so. Since 50 percent of the population derives drinking water from ground water sources, contamination, whether real or potential, poses a significant health threat. Establishments catering to the traveling public often derive water from ground water aquifers. In 1975, alone, nearly 800 cases of waterborne diseases were attributed directly to untreated ground water from such sources and unreported cases are probably more numerous.

Waste from animal feed lots, communitylandfills, toxic and hazardous materials, septic tanks and cesspools, and municipal and industrial discharges are proving to be major sources of contaminants of ground water in many locations across the country.

In areas dependent upon ground water for municipal, industrial or agricultural uses, continued degradation of ground water quality will have significant implications in the economies of the affected communities. One effect will be to raise the cost of treating water to achieve a suitable quality. Water quality degradation may render a ground water supply totally unusable.

The interdependence of water quality and quantity is well established, and is particularly true for ground water. Continued over-draft conditions, especially in coastal areas add to ground water quality problems through salt water intrusion of aquifers. Further, water use patterns usually involve ground water withdrawals, conveyance to users, and conveyance of waste waters to some other area. Such a use pattern may result in ground water depletion in one area and the loss of a useful resource to another. In this fashion, intra-basin and inter-basin transfers of water commonly occur. Such transfers may not have been specifically planned, but just happened as water supply needs were met and waste water treatment options were exercised. Special attention must be given to planning water use patterns so that the vital ground water resources of an area are not wasted through depletion.

Ground water depletion and quality degradation in the Lower Colorado and the Rio Grande Regions could be the source of some tension between Mexican and U.S. communities.

The extent of the relationships between surface and ground waters and the nature of both polluting and cleansing mechanisms that affect ground water aquifers must be better understood. Detailed quality and operational data need to be gathered on existing wells and new observation wells, and knowledge and understanding of ground water systems must be increased.

Specific Problems

High mineral content ground waters are found to be a problem in most areas of the United States. In addition, contamination of ground water aquifers has been indicated as almost as prevalent.

The following representative specific problems illustrate the distribution and variety of problems of ground water contamination. The information has been furnished by Regional Sponsors.

Lake Champlain (ASR 106)

Pollution of some ground water sources in the area is caused by improper sewerage disposal systems, overcrowding of individual systems in confined areas, or by leachate from landfills.

Brunswick, Georgia (ASR 303)

Ground water tables in the area are high and during rainy weather the septic tank tile fields may intersect ground water tables, thereby contaminating the shallow ground water aquifer with septic tank effluents. The ground water aquifer near the surface consists of sand and gravel and is used by individuals as a water supply source. Industry may also use this source.

Pascagoula, Mississippi (ASR 309)

Although ground water is plentiful, there are areas of Mississippi in which this abundant supply is degraded. In the Miocene-Pleistocene sands along the Gulf Coast there are areas of high iron content, low pH, and corrosive water. There are unknowns associated with deep-well injection of liquid wastes in some areas of the State. Of particular concern is the injection of oil brines associated with oil extraction.

Ozarks Area of Benton and Washington Counties, Arkansas (ASR 1104)

There is a lack of data on ground water. A small research project by the University of Arkansas revealed that, in the area included in the study, 80 percent of the ground water sources tested are polluted with coliforms. The study encompassed 100 square miles and results indicated that 90 percent of the area may be affected.

Santa Ana River Basin, California (ASR 1806)

In both the Upper Santa Ana Basin and in Coastal Orange County a ground water overdraft situation exists. Agricultural return flows, percolation of high nutrients, and total dissolved solids concentrations from sewage effluents have resulted in degraded quality of the ground water resources.

Jackson County-Port Lavaca, Texas (ASR 1205)

The mining of ground water has caused, and if not controlled, will continue to cause saline water encroachment, particularly along the coast where saline ground water overlies and flanks the fresh to slightly saline water in the aquifer.

Options for Resolution

To resolve ground water contamination problems, more needs to be known about ground water mechanisms and the fate of pollutants. A first order of business is the collection of a full range of quality data and well levels from existing wells and from new observation wells drilled for that purpose. These data should form the basis for analytical studies, including physical and mathematical modeling, of ground water mechanisms.

Septic tank problems stem from poor siting, construction, and operation. Alternative individual waste treatment systems need to be found and used so that both ground and surface waters are no longer contaminated by drainage from improper septic tank systems.

Interconnections between surface contamination or pollution and ground water aquifers need to be better understood and the information used to manage the resource. The same applies to interconnections between low quality aquifers and aquifers with high quality water. Old oil and gas wells, new well drilling, mining activities, and the like, are prime areas for such interconnections. A program of well casing or well plugging is desirable. Licensing and inspection of well drilling operations may be required. Methods of irrigation that minimize the leaching of salts from soils need to be encouraged.

The practice of solid waste disposal in landfills needs careful evaluation. Particularly troublesome is the problem of the disposition of toxic and hazardous substances. There is a need for more complete use of resources before final disposition. Conservation practices will tend to minimize the volume of material to be disposed of by landfill practices. Landfills need to be operated to minimize the possibility of leachates polluting ground water aquifers.

DOMESTIC WATER SUPPLY CONTAMINATION

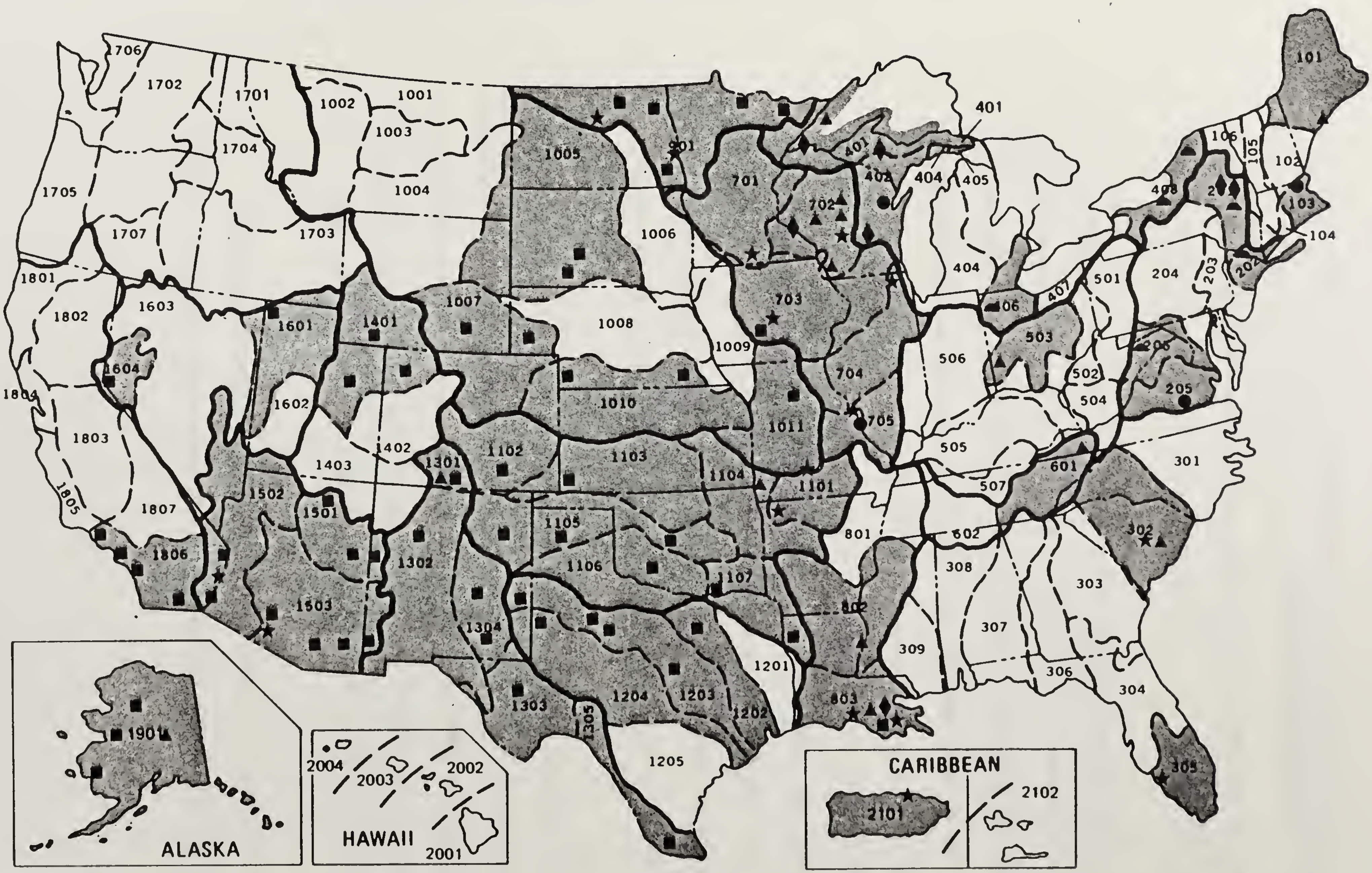
Problem Definition

A safe drinking water supply is of high priority for the good health of the citizens of the Nation. Strides in the provision of safe drinking water in the past 50 years have been so effective that the public has lost an awareness of the potential for serious disease that could occur with system malfunctions. The Safe Drinking Water Act (P.L. 93-525) was passed in 1974 to ensure adequate supplies of potable water and prevent serious crises in the coming years. However, the continued production, use, and discharge of toxic chemicals, if unabated, could contaminate much of the Nation's drinking water. This threat resulted in the enactment of the Toxic Substances Control Act of 1976 by the U.S. Congress.

Waterborne disease outbreaks are considered a rarity. Yet, in the five years from 1970 to 1975, an average of over 5,000 cases of waterborne illness, primarily of bacterial or viral origin, were reported annually. In 1975, nearly 11,000 cases were reported. Actual cases, including the more difficult to identify chemical poisonings, are undoubtedly more frequent.

Besides the threat of gastro-intestinal illnesses, increasing amounts of toxic substances threaten the Nation's water supplies. (Figure II-5).

Domestic Water Supply Contamination



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Areas with Greatest Total Impact

Areas with existing or potential problems due to toxic and hazardous materials in domestic water supply sources.

Location of Specific Impacts

● Industrial chemicals.

♦ Chlorinated hydrocarbons from treatment processes and energy development.

▲ Heavy metals.

★ High coliforms and bacterial contamination.

■ High mineral content or dissolved solids.

◓ General water supply contamination from municipal and industrial sources.

Figure II-5

- There are currently more than 2 million identified chemicals of which over 30,000 are already in commercial production.
- Little is known about the health effects of some of the new commercially produced chemicals; however, many are already known to have harmful health effects among which are certain diseases, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, physical deformities, and death.
- Many chemicals are toxic at concentrations not detectable with available measuring techniques.
- Many chemicals, transported by water, settle into bottom sediments or into ground water aquifers. These may enter the aquatic food chain and successively accumulate in the flesh of fish or other predators up the food chain.
- Many chemicals are not amenable to removal by conventional water or waste water treatment systems.
- Many chemicals, once in a water course or in a ground water aquifer, are able to combine with other chemicals to form new toxic or carcinogenic substances.

Heavy metals such as cadmium, copper, iron, lead, mercury, and zinc dissolved in water are lethal to fish even at very low concentrations. Cadmium has caused fatal bone diseases in humans, and lead and mercury have caused brain damage. Sources of heavy metals contamination include industrial discharges, urban runoff, pipe corrosion and infiltration in water treatment and distribution facilities, mining activities, and some instances are even found to be naturally occurring. In states along and east of the Mississippi, the primary sources of heavy metals are urban runoff and industrial discharges. In the less populated western states, primary sources are mining operations involving lead and zinc. They occur naturally as well.

Industrial chemicals such as cyanide, phenols, polybrominated biphenyls (PBBs), and polychlorinated biphenyls (PCBs) also are threats to human and aquatic life. PCBs have been found in both surface and ground waters. They do not biodegrade; they are carcinogenic; they have caused human poisoning and led to fishing bans in the Great Lakes, Hudson River, and other areas.

Organic compounds such as chloroform and carbon tetrachloride also pose serious concern because of their carcinogenic nature. Chloroform is formed by the interaction of chlorine, used as a disinfectant in both water and waste water treatment processes, combined with other organic residues, or with humus found in the stream bed.

Most surface waters receive extensive treatment at the community level prior to distribution. This treatment may include: disinfection, coagulation, sedimentation, and filtration, among other possibilities. Ground waters, however, often receive little more than disinfection, although approximately 50% of the Nations's population drinks ground water: 90 million via community systems and 35 million dependent on springs and wells.

Chemical quality deficiencies are perceived to be a problem, nation-wide; whereas, the question of toxics, heavy metals, and the like was identified in only a few of the aggregated subregions. The prevalence of water quality problems is believed to be more widespread than that shown. The problems of carcinogenicity will become major issues as it becomes more widely known that latency periods of up to 20 years are involved before disease symptoms can be identified.

In the past and in the absence of disease outbreaks, drinking water has been judged safe if minimum State and Federal standards have been met. More recent research has found that there has been insufficient water quality monitoring for the bacterial and chemical categories of concern. Starting in June 1977, all community systems are required to monitor and report deficiencies to both consumers and State level regulatory agencies.

Implications

The contamination of ground and surface sources of public water supplies has serious potential public health consequences. Any breakdown in treatment or distribution can cause widespread outbreak of waterborne illnesses. Increasing accumulations of specific pollutants in both surface and ground water supplies pose a constant threat, since water contaminated with organic, inorganic, radioactive, bacterial, and viral substances are known agents for the spread of either chronic or acute disease. Increasing concentrations of those pollutants in raw waters place a burden on conventional water treatment plant processes and on those who operate them.

Toxic and hazardous substances have been identified in waters of many areas. Transportation accidents involving these substances occur at widely diverse locations. Chlorinated hydrocarbons, heavy metals, cyanides and phenols, asbestos fibers, and a variety of other chemicals, either individually or in combination, pose a threat to human health. Harmful health effects from the ingestion and accumulation of these substances may appear years later.

Because of the increasing burden specific pollutant sources such as municipal and industrial discharges place on water supplies, an evaluation of the trade-offs between increasing waste water treatment costs and increasing risk to downstream water users appears necessary.

Removal of toxic and hazardous materials, when they are found in water supplies, normally cannot be achieved by conventional treatment processes. Industries are required by law to pre-treat wastes before discharging them to sewers. Effective, and possibly more expensive, treatment processes must be developed.

Spills of toxic substances are not fully preventable. Thus, substantial financial resources will also be required for development of monitoring equipment and techniques, health effects research, and development and installation of advanced treatment techniques.

Both the law and economic efficiency urge treatment of all wastes at point of discharge, where definable, to render them acceptable. Multiple in-plant reuse of water by means of recycling of water from high quality water needs to lower quality needs is feasible. Control practices to limit non-point source pollutant contributions will contribute to the preservation of our high quality water resources. Control of non-point sources and treatment of point sources of pollutants may make additional energy demands.

Specific Problems

The following representative specific problems illustrate the distribution and variety of problems of domestic water supply contamination. The information has been furnished by Regional Sponsors.

Lower Mississippi River (ASR 803)

Between St. Francisville and Venice, Louisiana, 60 industries discharge highly concentrated non-BOD-containing wastes into the Mississippi River. The extent of the pollution is reflected in the fact that fish caught in the river below Baton Rouge are not marketable because of off-flavors in their flesh. This reach, however, serves as a raw water supply for 40 utilities serving a population of one and a half million. Treated water supplies at two locations have been found to contain trace amounts of six organic chemicals capable of inducing histopathological changes in animals during chronic toxicity studies. Treated water supplies have furthermore been found to contain three organic chemicals described as carcinogenic.

St. Louis Vicinity (ASR 705)

Shallow ground water supplies are contaminated in localized areas with bacteria, nitrates, and other chemicals, particularly in northern Jefferson County and in the East St. Louis area. Inadequate solid and liquid waste disposal systems and improperly constructed wells result in the contamination of these shallow ground water supplies. Ground water intrusion is also a problem as a result of both natural and man-induced causes (pumping). Consequently, many areas are forced to utilize highly mineralized water supplies to meet their needs.

Lake Superior (ASR 401)

Asbestiform fibers in public drinking water may have long term effects on the area's health. An increase in the incidence of asbestos-caused cancer may not become apparent for many years. Taconite tailings increase the turbidity of Lake Superior waters and may be harmful to the aquatic life in the lake. Deep water spawning beds may be ruined. The taconite tailings dumped by Reserve Mining contain 35 chemical materials, including lead, mercury, cadmium, nitrates, phosphates, and silicates.

There is poor water quality in the St. Louis River from Cloquet to Lake Superior, affected by severely low dissolved oxygen levels resulting from industrial pollutants, organic wastes from paper and pulp mills, shipping vessels, urban runoff and discharges from shipping vessels and municipal waste water treatment plants. Water quality problems may be exacerbated by the operation of two of five upstream hydroelectric plants causing river flow fluctuations as well as the inadequate flow for dilution of many of the small streams.

Public water supplies are degraded by turbidity, color, taste, and odor in addition to asbestos contamination from taconite mining.

Middle Iowa River (ASR 703)

Restricted use of surface water as a potable water supply for domestic and livestock uses and as a suitable water supply for industrial processing and cooling purposes is due primarily to excess turbidity and sedimentation. Increased cost of water treatment for municipal and industrial supplies taken from surface water sources is common. Restricted use of untreated ground water as a potable water supply is due to excessive hardness and iron content problems.

Options for Resolution

Options for overcoming the problem of domestic water supply contamination are dependent on the full implementation of three federal laws: The Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500), The Safe Drinking Water Act of 1974 (P.L. 93-523), and the Toxic Substances Control Act of 1976 (P.L. 94-469). These laws deal with the control of discharges at the "source". The Safe Drinking Water Act of 1974 (P.L. 93-523) is also concerned with water supply in all its aspects from raw water to the product delivered to the consumer's tap. These concerns are being translated, in part, into regulatory programs to monitor, report, and control water quality at the consumer level and to identify and control numerous activities known to adversely degrade ground water quality.

Of great concern to communities is the potential high cost of monitoring water supply quality and high costs of laboratory testing. There is also concern that smaller systems may not be able to afford the technology to bring water quality within the full range of water quality standards presently promulgated in addition to those being proposed.

Low cost treatment techniques need to be devised to demineralize ground water. This problem is pervasive throughout the country and is a prime source of domestic water quality treatment problems. Also, low-cost, on-line monitoring techniques need to be devised to minimize the costs of satisfying the monitoring provisions of the Safe Drinking Water Act and to assist the stable operation of treatment systems.

FLOODING

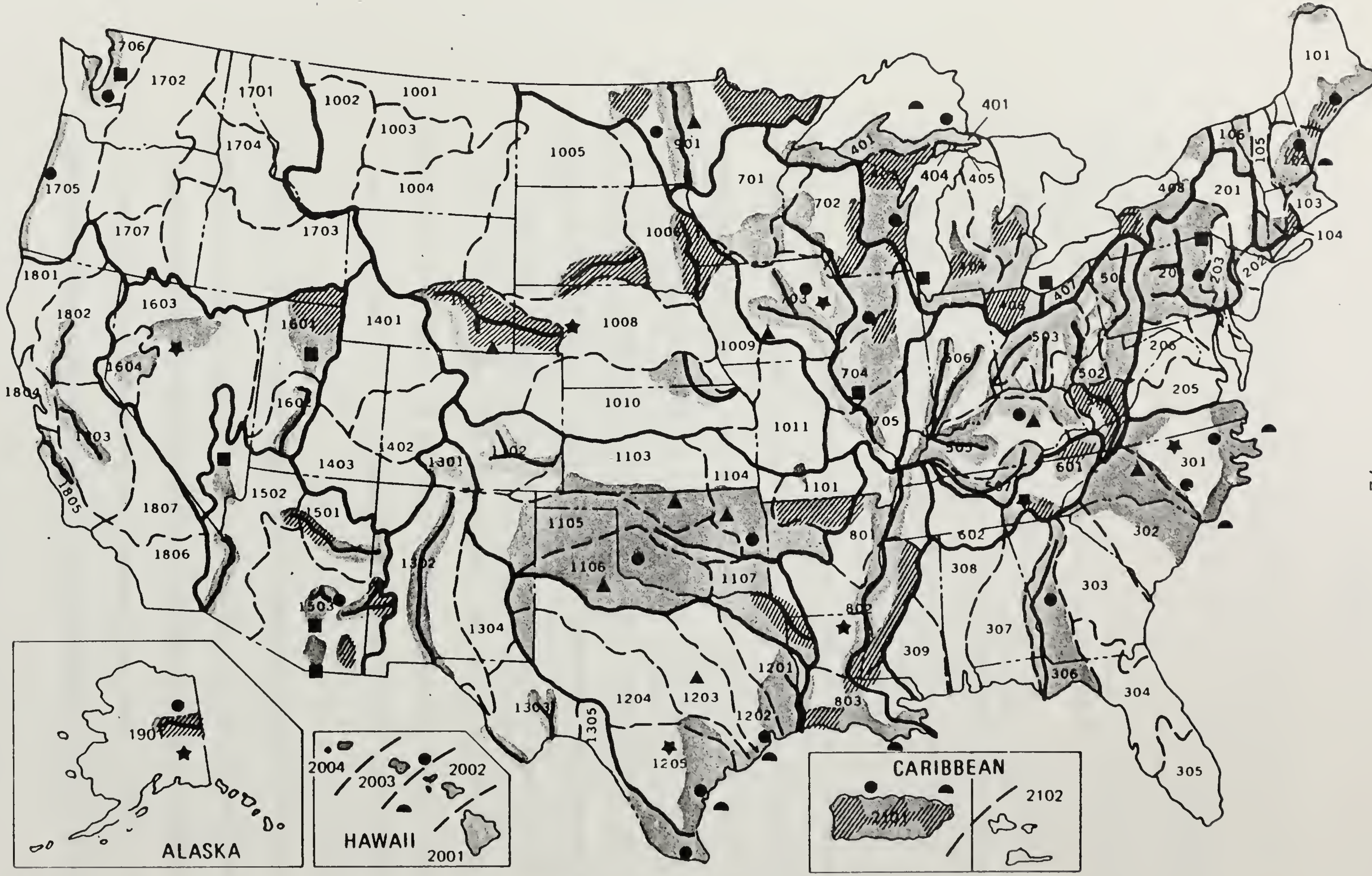
Problem Definition

Much of the most productive and beautiful land of the country is located in flood plains. The flood plain and its associated resources of adequate water, easy transportation, productive soils, abundant wildlife, and a moderate terrain have encouraged development on the plain. The location of large amounts of the productive economy in these areas has created a potential for large flood damages.

Flooding occurs when water in excess of the normal stream, lake, or bay capacity covers land other than natural banks. Flooding also occurs when rain, snow, or storms produce water on the land surface faster than the water can be carried away. And in some cases flooding is caused by massive tidal waves that inundate ocean coastlines. Floods are natural phenomena. But whatever the cause, flooding often results in heavy damage as crops, houses, livestock, and people are washed away by the enormous energy of moving waters. Approximately 83 people are killed in the average year, while actual property damages of $2.2 billion were estimated for 1975.

Almost no area is totally immune from potentially devastating flood water when heavy and prolonged rains fall in the humid areas of the Mid-west, East, Southeast, and Northwest, and when slashing thunderstorms produce flash floods in more arid areas, including the normally dry deserts of the Southwest (Figure II-6). In late winter and early spring

Flooding



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Areas with Greatest Total Impact

- Areas that have serious agricultural, urban, or other flooding.
- Areas that have moderate agricultural, urban, or other flooding.
- Major streams and stream reaches with periodic severe over bank flooding problems.

Location of Specific Impacts

- ● Flood plain encroachment.
- ■ Increased flood damage from accelerated runoff from urban development.
- ▲ Inadequate upstream watershed management.
- ★ Loss of flood control from inadequate structural systems.
- ◓ Flooding of coastal, beach, subsided, and other lowland areas caused by tides and storms.

Figure II-6

the melt of accumulated snow drives many streams from their banks. In late summer and early fall hurricanes and tropical storms often dump large quantities of water on the islands of the Caribbean and the Atlantic and Gulf coasts from Maine to Texas.

The enormous damages produced by flooding are borne by farmers, homeowners, businesses, transportation, and community services. Almost half of all flood damages accrue to agriculture as crops and livestock are destroyed and as productive land is covered or washed away.

The impact of flooding on wildlife, fish and ecosystems is mixed. In upstream areas wildlife, food, and habitat are often removed or covered by flood waters resulting in severe damage to the natural systems involved. Measurement of such damages in monetary terms is difficult; however, such natural systems have considerable aesthetic, recreational, and other values. On the positive side, flooding may transport substances that serve as beneficial nutrients that improve or assure existing natural systems in the downstream areas.

Implications

It must be repeated that floods are natural phenomena. When man intrudes upon the floodplain he adds to the disruptions which occur from time to time. The history of man's activities is convincing evidence that, for whatever reasons, he has chosen the floodplains as being generally more desirable for his activities. Whether this is by conscious decision or tradition, the implication is that unless the Nation is prepared to force reduced activities in flood-prone areas it will have to continue to provide the services the populace has come to expect: structural and non-structural flood protection, education and insurance programs, and periodic financial assistance to flood-damaged areas.

Although floods occur naturally, they can be accentuated by man's activities. Thus, although programs to evaluate flood potential (for example, defining and describing the 100-year flood plain) are of value, future growth and construction upstream and/or downstream can all too quickly cause a local situation to be worsened. A home built within the 100-year flood plain line could find itself later at the 50-year level.

Even more important, however, is that people in general do not comprehend the implication of "100-year" or "50-year" floods. Although the probability of occurrence of a 100-year flood next year is only 1% the possibility of its occurrence is 100%½ Furthermore, because a 100-year flood might have occurred recently does not in any way preclude the possibility that it will occur again (and again) in the near future. On the other hand, floods (like droughts) take on less meaning to the populace as the time from their occurrence increases.

Structural and nonstructural controls exist for reducing damages associated with flooding. Structural solutions provide for the design and construction of reservoirs, channel improvements, and small watershed structures that delay or divert excessive water to reduce flood damages. Nonstructural solutions seek to remove potential flood victims and property form the paths of oncoming floods. Such solutions are accomplished by warning systems that temporarily remove people and some property from the path of floods and by flood plain management programs that restrict land use in areas of high flood potential.

Both structural and nonstructural solutions have a place in an overall flood protection plan. Each must be evaluated in light of the potential for reducing damages. Approximately $13 billion have been spent since 1936 by the Federal government for structural flood control measures and over $40 billion in reduced damages are estimated to have accumulated. Structural measures for controlling flood damages may disrupt or destroy natural ecosystems. Totally assessing the value of such disrupted systems is not possible under current procedures.

When structural and nonstructural approaches fail to control flood damages provisions are made for modifying the impacts of floods. Federal payments of large amounts of disaster relief have been prompted by repeated calls for help from those who have been displaced or damaged by floods. In the period 1970-1975 approximately $1.3 billion were paid in flood disaster assistance. Provisions for additional aid have been made in the National Disaster Relief Act of 1974. Following a large and devastating flood, people will often relocate in the potentially floodable area.

Flood damage is primarily a problem of flood plain management. Since the passage of the Flood Control Act of 1936, the average annual damage from floods has risen year after year despite the expenditure of billions of Federal dollars on flood control measures. This increase is due in part to continued and expanded use of the 140 to 180 million acres of land in flood plains. Yet no structural solution can totally guarantee that flood damage will not occur. Development of intensive urban uses and extensive agricultural, recreational, and other uses simply places more costly items into the path of potentially devastating floods. The risk of such floods can be estimated, but the forecasting or timing of actual floods is not possible. A logical approach to flood control is to remove highly vulnerable properties from the high-risk flood plain areas. Although many roadblocks stand between such flood plain management and a reasonable level of flood protection, progress is being made.

In recent years the Federal Government has called upon local governments to aid in the modification of susceptibility to flood damage through flood plain management. For example, the Water Resource Development and Protection Act of 1974 calls for the consideration of nonstructural solutions to flooding problems as well as traditional structural solutions. Flood plain management programs generally require restrictive land use in the flood plain and can be combined with Federally subsidized flood insurance programs, floodproofing of existing properties, relocation from flood-prone areas, and acquisition of flood plain lands for extensive public use. Federally-subsidized flood insurance initiated by the National Flood Insurance Act of 1968 requires that participating communities provide some form of flood plain management. Currently over 13,000 communities are participating in the flood plain insurance program.

Increased value of properties in flood plains has pushed the levels of flood damages continually upward. These trends are expected to continue toward the year 2000 when it is estimated that without increased flood plain control $3.5 billion in potential annual flood damages will exist. Flood plain management could significantly reduce the levels of urban damage, but in agricultural areas, the effect of flood plain management would be less dramatic. Local pressures from those seeking low cost, easily usable lands, may divert local flood plain management, unless the risks of flooding are brought to bear more directly on those occupying the flood plains, including developers who sell to an uninformed public.

Total potential urban flood damages of $754.4 million in 1975 are expected to increase nearly 90 percent by the year 2000 unless there is increased flood plain management. Agricultural flood damages are not expected to grow as rapidly, but they are widespread. If the Federal Government is to continue to provide assistance on demand for flood damage, the effect on the National budget may be of major consequence.

Loss of lives is often experienced in floods. An average of 83 persons die each year in this Nation as a result. But the number varies greatly; in 1972, for example, 554 lives were lost due to floods. No amount of structural flood "proofing" will eliminate the loss of lives and property because it is simply not possible to protect against all possible eventualities. And even though Figure II-6 presumes to show many areas of the country without serious flood problems, floods can and will occur almost anywhere. Although few would admit to placing a monetary value on human lives, in flood protection programs it is done by the day-to-day decisions concerning the amount of investment in flood control made by engineers, administrators, legislators, and other citizens.

Public health is often a major problem associated with flooding. In urban areas, flood waters often disrupt public services, including water supplies and sanitary sewers. Local, domestic, and public water supplies are contaminated and untreated sewage is disseminated by passing flood waters. Such contaminated flood and domestic water carry potentially damaging diseases. Health problems persist well after the flooding has stopped as pools of flood water increase the number of breeding places for disease carrying insects.

Flood control programs (or the lack thereof) can have both positive and negative implications for environmental quality. Structural programs in particular can cause major problems because of the changed hydraulic and hydrologic characteristics. Developed ecosystems are adapted to and depend upon the natural conditions of flow. Periodic high flows, inundation of flood plains, and introduction of sediments are all part of natural conditions. Thus, channelization or construction of reservoirs will cause changes. The continued increase of urbanization with subsequent covering of fields by concrete and asphalt creates different flow conditions and water quality. Facilities intended to pass flood flows quickly from one area may cause the problem to be aggravated downstream. They can also result in the reduction of ground water recharge. Not all of the so-called environmental effects are negative nor are they necessarily permanent, for new ecosystems (different, but possibly equally valuable) will establish themselves. It is important to understand that every change in a stream system will have an effect and that these are factors that should be considered when decisions are being made on flood control measures.

Local and national economic efficiency is lost as flooding disrupts residential, industrial, and agricultural sites. Agricultural damages in 1975 were estimated to be approximately 2 percent of the value of the national agricultural production. Individual farmers and consumers as an aggregate incur these damages. All regions of the country report net agricultural losses from floods. Under the most likely conditions for the year 2000, agricultural damages are expected to reach $1.1 billion annually. In 1972, total flood damages were approximately $4.5 billion. In 1974, property valued at some $500 million was lost. Such losses, even when partially offset by disaster relief, mean substantial personal loss to the individuals and communities involved. When lives lost in floods are considered, the impact takes on even greater significance.

International relations do not seem to be significantly affected by flooding in the United States except in limited areas along the Mexican and Canadian borders. The flooding Red River of the North causes damages in both the U.S. and Canada. Similar problems occur along the Rio Grande border with Mexico. International agreements may be desirable to reduce flood damages in these areas.

The urgency for reduction of flooding problems has decreased in recent years as major flood control structures have reduced the potential impacts of the more dramatic flooding problems along major rivers.

Although local problems may be extremely important due to large potential damages, the recognition by individuals, firms, and local governments of the risks associated with flooding could reduce the overall national urgency. However, the rapid development of flood plains throughout the country and the tremendously increased damage potential highlights the importance of the problem. Thus, without some type of flood control program, the problems will become more serious in the future.

Specific Problems

The pervasiveness of flooding provides many examples of specific problems. Several example problems serve to illustrate the prominent types of flooding and flood damage which exist throughout the United States. Regional Sponsors for the Assessment have furnished information on which the following is based.

Tropical Storms

Late summer brings annual climatic changes that produce major tropical storms and hurricanes in the Atlantic Ocean, Gulf of Mexico, and the Caribbean. Such storms struck the Texas coastal area in 1967 (Beulah), 1970 (Celia), and 1971 (Fern), resulting in the inundation of large areas by extensive rainfall and high tides. The destructive potential of these storms reaches hundreds of miles inland, affecting agricultural production as well as domestic, urban, and business communities. Direct damages from these storms ranged between $54.6 million

(Beulah) to $22.6 million (Fern), with much of the damage occurring in the same ten counties of Texas. Numerous deaths occurred in these floods.

Early warning systems and structural developments, such as flood walls, prevented the damages from being even higher. The residents of these areas have experienced many similar storms and heed early warning reports which track each storm's progress. Preparations for the storms are generally extensive as the residents of the area assume some, if not all, of the risk associated with living in a flood-prone area. Correspondingly, home, auto, and personal property insurance rates are higher as risk is shared commercially. Federal assistance is often required as a result of such storms. Continued use of warning systems and flood education will prevent extreme loss of life and property. The development of additional drainage in the Lower Rio Grande Valley would relieve some of the agricultural damage experienced in that area.

Flash Floods

Severe thunderstorms that deposit large quantities of rain in short periods of time on areas of low density vegetation cause rapid-rising or flash floods. Such floods often catch residents without warning, such as the Big Thompson flood of Colorado (1976), or the Jamestown, West Virginia flood (1977), or the Johnstown, Pennsylvania (1977). Many areas of the Southwest are perennially subjected to such flooding in rainy seasons, the urban area of Las Vegas, Nevada being an example.

The Las Vegas metropolitan area is arid with sparse vegetation and low rainfall (3.76 inches per year average). Rapid development has produced many expensive structures and related items in flood-prone areas. Floods resulting from thunderstorms cause severe local floods. Such floods have occurred periodically throughout the last 50 years with each succeeding flood bringing greater damage. A combination of flood plain information, planning, and structural diversions is needed to reduce damages in the Las Vegas Valley. These elements should be organized in a comprehensive flood control plan for the area.

Middle Mississippi River (ASRs 704, 705, and 801)

Snow melt and heavy rainfall over a large drainage area causes frequent flooding along the Middle Mississippi River. Such long-duration, slow-rising floods covering large agriculutral and urban areas of the relatively flat Mississippi Valley occurred in 1973 and 1974. Extensive agricultural damage has been reported on the highly productive lands along the river. Estimated annual damages of $17,400 per mile are projected by 1980 along the Middle Mississippi main stem. High annual damages are projected for most cities along the river. For example, Hannibal, Missouri, is a low-lying city incurring damages of approximately $3.3 million annually. Projected downstream damages of $55.3 million annually are anticipated by the year 2000 with agricultural damages being 45.6 percent of this total. In the year 2000 agriculture's proportion of the total damages will be somewhat lower than in 1975 as the value of nonagricultural properties in the flood plain increases rapidly.

Structural and flood plain management would reduce future property damage. Loss of life is usually minimal since flood warning systems are effective in estimating arrival and height of flood peaks of these almost annual floods on the main stem.

Lower Mississippi River (ASRs 802 and 803)

Flooding similar to that of the Upper Mississippi main stem has a dramatic impact on the Lower Mississippi main stem. The Mississippi River serves as drainage for 41 percent of the nation, much of which has abundant rainfall. Approximately one-third of the Lower Mississippi Basin is subject to flooding. The floods of 1973 and 1974 lasted for some eight months and included runoff from heavy snow melts, and fall and spring rains. The net result was some 13 million acres of flooded lands in the Lower Mississippi Basin, $760 million in property damage, and 28 deaths. These flood damages were reduced in part by the Mississippi River and Tributaries Project which is approximately 50 percent complete. Total expenditures of $3.1 billion on the project have accumulated $55 billion in avoided flood damages. The project, which has caused problems in terms of disturbed wetlands and other environmental concerns, attacks a flooding problem which produces $260 million in average annual losses and is described as the most urgent problem of the basin.

Options for Resolution

The problem of flooding can never be totally resolved. Only through a cooperative effort between Federal, State, and local governments; private individuals; and industry can adequate protection from flood damages be offered. Controls for flood damage can take three general forms: (1) modifying susceptibility to flood damage and disruptions, (2) modifying floods, and (3) modifying the impact of floods. Each form has a place and a function in an overall flood damage control program.

There is a need for flood damage control measures that offer maximum protection from damage while simultaneously recognizing the risk components of the problem. Thus, paramount on the list of options is the expansion of information and education on the risks associated with flood plain occupancy. Farmers, developers, and property owners must assume some of this risk or transfer it to a third party through flood insurance. This risk acceptance may be tempered with flood plain management enforced by regulation. However, in developing flood control strategies, emphasis should be placed on economic controls which reduce the need for regulation and political solutions to land use questions. Such strategies could lead to lower Federal expenditures for flood control. The current approach transfers much of the risk to the Federal government which attempts to modify floods and provide emergency flood and post-flood recovery measures. Some shifting of the responsibilities of flood risk from the Federal government to property owners and local governments could improve local systems of control. The Federal government could continue an active role by providing or guaranteeing loan funds from which structural and nonstructural programs could be financed by innovative local concerns. Active Federal warning, information, and educational systems could offset some of the funds currently spent on flood relief programs, structural measures, and substantially benefit local programs. The leadership for increased local participation would need to come from the Federal system.

Continuation of the current system of dominant Federal participation is also an option. Because of the role of such agencies as the Corps of Engineers and Soil Conservation Service in assessing, designing, and implementing flood control programs, substantial knowledge has been developed. The risk currently assumed by the Federal government has in the past been classified as a legitimate national interest. Under this assumption, large expenditures for structural solutions and flood relief would accompany increased attempts at flood plain management. Building up the various aspects of flood plain management, flood plain information, and flood warning systems will aid these attempts at flood damage controls. The provision of Federal disaster relief would be a continuing requirement unless more of the responsibility can be shifted to flood insurance programs.

Technical solutions for flood damage control seem to be well established. The resolution of specific problems through structural measures alone may compound future damage by providing a false sense of security. Nonstructural solutions involving regulations are complicated by long-standing property rights and associated land uses which can only be changed in the long run. However, information, education, and risk transfer through insurance provide additional mechanisms for mitigating the impacts of floods. Some combinations of these options with local, State, and Federal participation will be required to reduce flood damages. Floods will continue to exist as major natural events and they must be countered by ingenuity as well as technology.

EROSION AND SEDIMENTATION

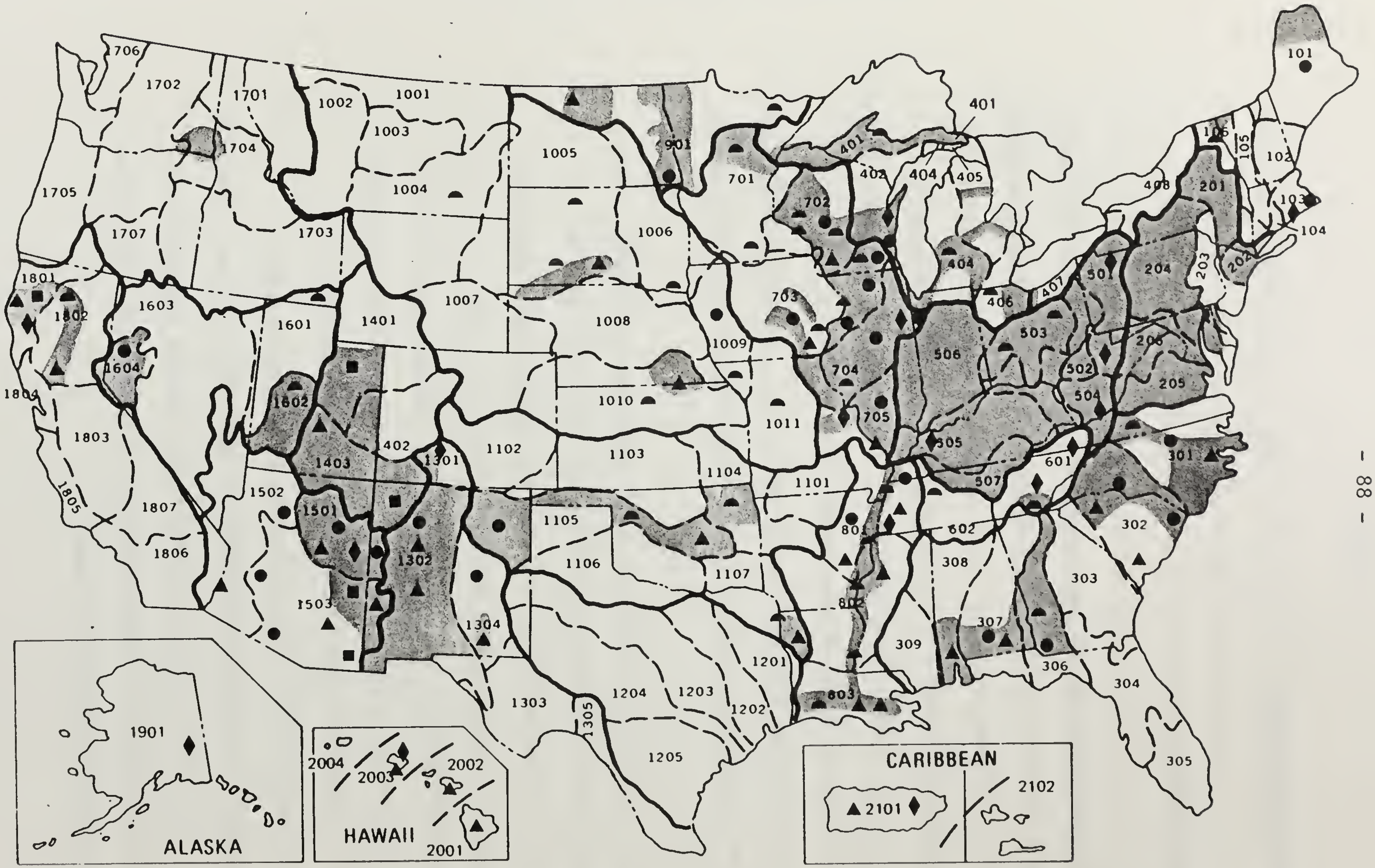
Problem Definition

Erosion and resulting sedimentation are among the most pervasive water related problems in the Nation (Figure II-7). Severity of erosion is greatest in the humid areas of the country. Gullying, streambank erosion and shifting sands along the coastlines are more obvious than the uniform wearing away of the land mass. Often erosion and sedimentation accelerate as human activities disturb the natural setting, but because the process is slow the effects often go unnoticed. Erosion from natural causes is more prevalent in the arid West because of a lack of protective cover.

In agriculture, which depends on soil and plant management, there is little short term incentive to control the soil loss that often impairs long term land productivity. The 1975 average cropland soil loss from sheet and rill erosion by water was 8.6 tons per acre and an average loss for some areas exceeded 25 tons. Overgrazing of pasture lands reduces plant cover which accelerates erosion. Erosion depletes the long term productive capability. Forest related activities of timber harvest and off-road recreation also accelerate erosion.

In urban areas, runoff from residential and industrial development and highway construction carries sediments into streams and reservoirs. As surface mining expands to support national energy needs, the erosion potential from these lands will increase.

Erosion and Sedimentation



Legend

Areas with Greatest Total Impact

Areas that have serious erosion.

Location of Specific Impacts

● Serious loss of productive capacity of cropland and rangeland.

♦ Serious erosion from urban, industrial, mining, and highway construction.

▲ Serious sedimentation problems in farm ponds, lakes, water supply and flood control reservoirs, and stream channels.

■ Serious natural or geologic erosion.

◓ Serious shoreline, stream bank, or gully erosion.

Figure II-7

Channel banks, beaches, and shorelines are likewise threatened by the scouring action of flowing waters. Wakes from barges and ships, construction activities, and changes in river flows from impoundments by reservoirs damage useful shorelines.

The sediment from the various types of erosion is carried into streams suspended in the water and deposits when streamflow diminishes. This causes sediment buildup in slower stream reaches, causing a further slowing and spreading of the flow. Sediment is deposited in lakes and reservoirs causing a loss of water storage capacity. Low-lying lands along rivers are often covered with sediment. Sediment acts as a carrier of pollutants such as phosphates and pesticides. Sedimentation adversely affects environmental quality of water bodies by covering fish and wildlife habitats, damaging spawning and nesting areas, and impairing fisheries.

Erosion and sediment by their nature affect both private and public land and water users. Strong local, regional and national programs are needed to control erosion and reduce sedimentation.

Implications

Erosion and sedimentation affect virtually every area of the United States. The depletion of the land base is of major concern as additional pressures increase extraction of natural resources from crop, forest, and range land, and through surface mining. Erosion of the land base causes local economic decline over long periods of time as economic feasibility of continued agriculture and silviculture declines. The cost of soil depletion is often beyond the planning horizons of individual farmers and ranchers. The economic impact of sedimentation is in a major sense generally borne by a second party or by the public sector rather than those who own or operate the land on which the erosion occurs. Thus, poor economic incentives exist for proper practices to keep soil on the land. Although the loss of production from eroded land is primarily of long range concern, in the short-term the related water quality and sedimentation problems are more generally urgent.

Sediments suspended in water flowing over the land carry nutrients and pesticides into the rivers and lakes. These pollutants increase the rate of eutrophication of water bodies and are a potential hazard to public health. Aquatic habitat is damaged by siltation and the introduction of nutrients and pesticides. Marine life is altered or destroyed. Aesthetic values are affected. Dirty water is not attractive for fishing, swimming, boating, or viewing.

The cost of constructing and maintaining reservoirs and water supply systems will increase if soil loss increases or continues at present levels. Sediment accumulates in reservoirs and extra storage must be provided to accommodate it. Sediment must be removed from water supplies before they can be delivered to users. Sediment clogs irrigation systems and its removal requires constant maintenance. Navigation channels require periodic dredging to maintain adequate depths.

Silt deposits can be beneficial to certain low areas as they add rich soil but, in most instances, the silt deposition damages crops, orchards, residential improvements, roadways, and structures.

Specific Problems

The following representative examples of erosion and sediment problems illustrate their widespread nature and variety.

The information was furnished by Regional Sponsors.

Upper Mississippi River (ASRs 701-705)

The main stem of the Mississippi River between Minneapolis-St. Paul and St. Louis suffers significant erosion damage. The highly erosive character of the loess soils and glacial ridges combined with increased flooding and changing shoreland uses have accelerated these erosion problems. Sediment deposited in the river bed requires maintenance dredging for navigation. There is major sediment damage to fish and wildlife habitat and to recreational areas along the river. In the area of Wisconsin adjacent to the main stem of the Mississippi River over 800,000 acres or 57 percent of the land needs soil conservation treatment. Almost eight percent of this area has annual soil losses in excess of 20 tons per acre. The average daily sediment load of the Mississippi River at Hannibal, Missouri, is over 70,000 tons per day. This increases to about 500,000 tons per day at St. Louis.

Lower Mississippi River (ASRs 801-803)

Sedimentation in the Mississippi River reduces navigation depths and deep-draft access to the ports of New Orleans and Baton Rouge, Louisiana. In order to maintain deep-draft port access, dredging operations must be performed from January to November each year to remove material deposited on the channel bottom at various locations in the Mississippi River below Baton Rouge.

Man-made levees and jetties cause Mississippi River sediment to be carried into the Gulf of Mexico beyond the 100-foot depth contour. The average annual transported sediment load in the Mississippi at its mouth is 300 million tons which amounts to an average rate of 825,000 tons of sediment per day. Studies indicate that the sediment load of the Mississippi River, if properly controlled, could create new land at an average rate of about 12 square miles per year.

Hiwassee-Little Tennessee Rivers (ASR 601)

Erosion and sediment problems are serious in these two drainage areas in the extreme southwest corner of North Carolina, the southeast corner of Tennessee, and along the mid-northern border of Georgia. Land-use pressures are increasing in this area because of its beauty and numerous recreational opportunities. The rugged terrain increases susceptibility to erosion from highway construction, second-home development, logging operations, and farming.

Erosion over the problem area averages nearly 37 tons per acre per year. When the runoff carrying the eroded material reaches the streams, it creates adverse effects both as suspended solids and bottom sediment. As suspended solids it increases the turbidity of the water, cutting down on light penetration and reducing photosynthesis. A more direct effect on the fish occurs to their gills which tend to become irritated and even clogged. Also, some sight-feeding fish like bass and trout, have difficulty locating food. Consequently, fishermen do not do well under these circumstances. As the suspended solids settle they tend to smother benthic organisms in the stream bottom and to cover the spawning areas of some reservoir fish. The capacity of the streams and the reservoirs is reduced by sediment. If the problem is not solved there will be increases in the amount of severely eroded land which presently totals about 700 acres, as well as increases in the damage to roadways.

Sheboygan-Green Bay (ASR 402)

This area includes that portion of Wisconsin adjacent to Lake Michigan from the City of Sheboygan north to the end of the Door peninsula between Lake Michigan and Green Bay. Gully, bank, and sheet erosion and sedimentation are prevalent over much of the problem area. Red clay erosion is a problem in the streams of the Sheboygan and Manitowoc River Basin. In Kewaunee County new construction activities are taking place on medium to steep slopes with attendant larger amounts of erosion. Sediment damages of the following types at significant levels or quantities were reported by the following counties:

- Sediment problems in roadside ditches and drainage channels - Kewaunee County;
- Deposition of sediment in storm sewers, on streets, etc. -- Brown, Calumet, and Sheboygan Counties;
- Muddy or turbid conditions in lakes or ponds used for recreation -- Calument, Kewaunee, and Sheboygan Counties;
- Damage to fish and wildlife and their habitat -- Brown, Calument, Manitowoc, Sheboygan, and Kewaunee Counties; and
- Abnormally high nutrients levels in water bodies from non-point sources -- Brown, Calumet, Kewaunee, Manitowoc, and Sheboygan Counties.

Rio Grande Headwaters (ASR 1301)

The expanding use of recreation vehicles on hiking and mountain roads in the mountain drainage to the upper Rio Grande in southern Colorado are creating an erosion and sediment problem. There is need for improved roads, hiking and skiing trails, campgrounds, and picnic areas.

Graham and Greenlee Counties, Arizona (ASR 1503)

Graham and Greenlee Counties are located in southeastern Arizona. Among the problems identified in this area were severe erosion occurring particularly on the desert and grassland and excessively high sediment content of Gila River. The high sediment concentration in the Gila and San Carlos Rivers increases maintenance costs of irrigation facilities, constrains water storage development, reduces the life of existing water storage facilities, and degrades recreational and fishing resources. Floodflows of the intermittent San Simon River contribute large sediment loads to the Gila River.

Upper Roanoke (ASR 301)

This twelve-county problem area lies in south-central Virginia and north-central North Carolina in the Piedmont and Blue Ridge Provinces. Almost 11,000 acres in Virginia and 11,000 acres in North Carolina are subject to erosion damage. The total Roanoke Basin has 5,983 miles of stream of which 391 bank miles are subject to erosion.

In the Blue Ridge and the Valley and Ridge Provinces stream bank erosion is moderate and generally confined to reworking of alluvial material. In the upper portion of the Piedmont Province much of the area is wooded and of such characteristics that little stream bank erosion occurs, but in the lower portion of the Province bank erosion, especially during periods of high water, becomes more pronounced.

Erosion attacks not only pre-worked alluvial material, but also the weathered metamorphic rocks beyond the alluvial flood plains. Stream bank erosion reaches a maximum in the upper Coastal Plain Province.

Land use in 1967 in the Roanoke Basin was 18 percent cropland, 14 percent pastureland, 65 percent forests, and 3 percent other. The relative erosion of these lands shows that well maintained pasturelands have soil losses about twice that of forest lands whereas cultivated lands may lose 10-100 times as much soil as forested lands.

The steeper mountain slopes have rapid runoff but are often forested so that soil losses are low. The highly erodable Piedmont soils have moderate slopes and are utilized for crop production to a great extent. This area is subject to much erosion.

The 200-square-mile area draining into Hyco Lake is typical of the Piedmont area. The area is sparsely populated, has rapid runoff conditions, and soils are composed mostly of sandy clay loams. Average annual sediment yields ranged from 98 to 333 tons per square mile for three headwater streams which flow into Hyco Lake on the Hyco River, a tributary to the Roanoke, in Person County, North Carolina. The sampling station two miles below Hyco Dam had a yield of 12 tons per square mile, the remainder from upstream tributaries having settled in Hyco Lake (19,000 ton/year or about 9 acre-feet/year).

For the water years 1969 and 1970 the average annual sediment measured in the Roanoke River at Randolph, Virginia (drainage area 2,977 square miles) was 60 tons per square mile or about 0.1 ton/acre. During the period 1950-1959 sediment accumulated in John H. Kerr Reservoir at a rate of 1 ton/reservoir acre/year or twice the rate anticipated when the project was designed.

Options for Resolution

There are numerous methods to reduce erosion and sedimentation. Management of the use of erosion-prone land is a logical starting point. Erosion can be reduced by limiting disturbance of soils that erode easily because of their make-up or location, such as on steep slopes. Construction activities, tillage, or grazing of this land could be limited through restrictions on public land and financial incentives or penalties on private land.

Positive steps can be taken to control erosion. Such steps can include planting and maintaining vegetation on erosive soils. The time that soils are exposed during highway or other construction can be minimized. Many agricultural practices can be altered to help control erosion. Tilling and planting on the contour, fertilizing, adding manure, leaving crop residues, and alternating row crops with pasture all retard water runoff and erosion. Irrigation practices can also be adjusted to reduce the erosion caused by spreading water over the land. Minimizing the slope of the land to that necessary to keep the water from ponding will reduce the erosiveness of the flowing water. Shorter lengths of field, alternate furrow irrigation, and reduced tillage also help. Structural measures that are helpful include grassed waterways, sediment filters, settling basins, and the installing of grade stabilization structures.

Erosion from pasture can be reduced by keeping stock numbers down to avoid overgrazing. The addition of fertilizer and replanting as necessary are also helpful. Stock should also be limited to the carrying capacity of range land. Other practices to reduce erosion of range land include selection of the type of grazing animals, brush management, range seeding and fencing, and location of water to avoid concentrating the stock.

Forest areas will have less erosion with controlled grazing, prescribed burning, firebreaks, planned modern harvest operations, controlling the size and location of clearcut areas, and managing to improve the timber stand.

Strip mined areas require a specific site-oriented reclamation plan. Such a plan could include slope alterations, vegetative cover, and structural measures to control water and sediment flow.

Erosion from areas of urban and highway development can be reduced by good planning and implementation of controls. The area and duration of soil exposure should be minimized. Open areas could be covered with mulch or seeded to grass if exposure is of long duration. Structural measures can be taken to reduce water flow rates or divert the water from open soil areas. Sediment can be trapped in water storage areas.

Stream banks can be protected by structures, hand-placed or dumped stone, or by vegetation.

In the final analysis, implementation of the existing methodologies and those that will be developed by further studies and research will probably require incentives and/or penalties. Although the problem has regional and national implications, it is probably best handled at the State level as an ongoing part of P.L. 92-500.

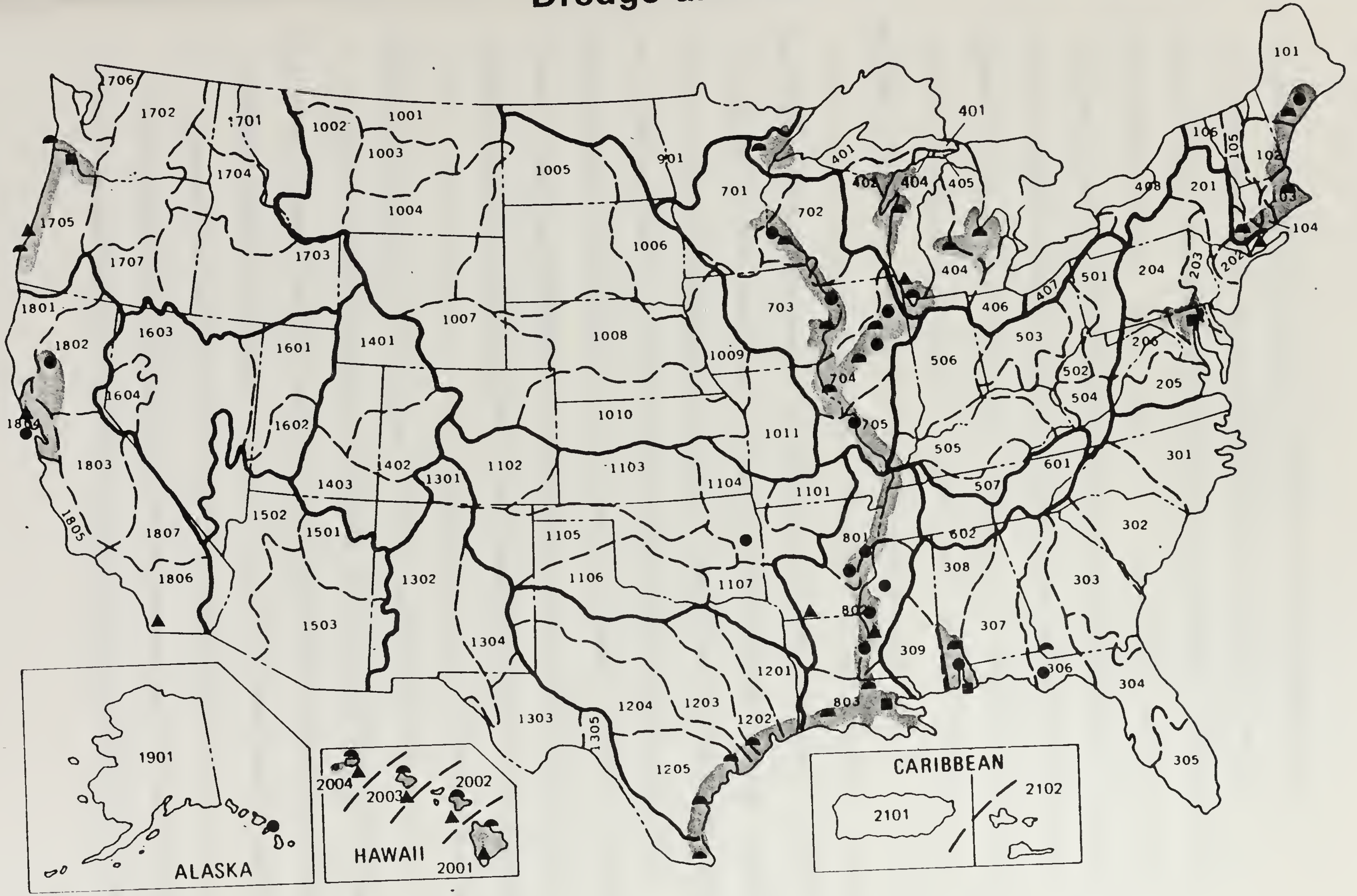
DREDGE AND FILL

Problem Definition

Channel dredging for navigation is necessary to maintain effectiveness of the national transportation network. The United States has 25,000 miles of inland and intracoastal waterways, the Great Lakes-St. Lawrence Seaway system, and numerous ports and harbors (Figure II-8). The Mississippi River system is the largest and most improved component of the inland waterways with 9,000 miles of navigable channels, 65 percent with depths of nine feet or more. The Gulf Intracoastal Waterway and tributaries contain 5,400 miles of navigable channels, 50 percent with a nine-foot or greater depth. The waterways of the Atlantic Coast include the Atlantic Intracoastal Waterway and the waterways in New York and New England with their tributaries. There are 7,000 miles of navigable channels on the Atlantic Coast, 60 percent with nine-foot depths. The Columbia River-Snake River navigation system and the channels extending inland from San Francisco Bay are the principal waterways of the Pacific Coast. Sixty-five percent of the 3,600 miles of these channels have a minimum depth of nine feet.

Navigation is an important part of the Nation's economic system. Large amounts of bulk commodities are moved through this system because it is the least expensive form of transportation for these products. Over one-half of these commodities are energy related, i.e., coal and petroleum and their products. Also, recreational boating has grown rapidly on the navigable waterways in recent years.

Dredge and Fill



Legend

Areas with Greatest Total Impact

Areas that have major dredge and fill problems.

Location of Specific Impacts

● Problems in maintaining channels.

■ Problems in deepening channels for deep draft vessels.

▲ Problems in land and waterfront development.

◓ Damage to fish and wildlife habitat.

Figure II-8

The continuing use of the waterways requires that depths be maintained. The erosion and sedimentation problem has been described in the previous section. The tremendous volumes of sediment deposited in the navigable streams, reservoirs, and harbors require regular removal and disposal. If the Nation is to avoid national and international dislocations in marine transportation, major ports and access channels must continue to be dredged to accommodate modern deep draft vessels. Because of the efficiency of waterborne commerce, demands for harbor and channel maintenance will probably expand with the development of larger transport vessels. Dredging and the disposal of dredged materials, however, can disrupt or destroy aquatic life necessary for commercial and recreational fishing, upset ecological balances basic to wildlife, and adversely affect water quality and other environmental balances.

Anticipated development of the Outer Continental Shelf in the Atlantic and Gulf region for oil and nuclear power plant siting will add to existing problems of open-water disposal of dredged materials. Along with these off-shore developments supporting on-shore developments will emerge which will involve dredging.

Loss of wetlands through either dredging or filling removes valuable wildlife habitat, and destroys nursery and breeding areas for marine fish and shellfish. The natural anti-erosion barrier and sediment traps provided by wetlands will also be lost. In addition, dredging causes suspension and sedimentation problems. Sedimentation impairs water quality, and destroys bottom habitat for aquatic species important to commercial and recreational fishing. Federal and State laws are now curtailing the loss of wetlands from dredge and fill operations.

In the Great Lakes border areas, dredging causes the degradation of water quality for fisheries and wildlife in the five lakes and adjacent water areas.

Dredging and filling have both short-term and long-term effects that need careful scrutiny so that appropriate management policies can be formulated.

Implications

Continued dredging to maintain waterways is destined to become more expensive as sediment continues to deposit and legal restriction on site location and dredging methods become more restrictive in order to protect environmental values. Severe marine transportation dislocations will probably occur if major ports and their access channels cannot be dredged to appropriate depths for accomodation of modern deeper draft vessels. Disposal of dredged material without appropriate environmental consideration can adversely affect sport and commercial fishing through habitat degradation or loss.

Dredging can affect water quality and create the problem of disposal of polluted dredged material. Much of the bottom material in the channels of the major ports is contaminated by accumulations of industrial wastes. Sites are needed for the disposal of this polluted material.

Loss of wetlands through either dredging or dredge material disposal represents the loss of a valuable wildlife habitat, reduction of a food resource and nursery/breeding area for marine fisheries and shellfishes, and loss of a natural anti-erosional barrier and sediment trap. Suspension of bottom materials through dredging and discharge impairs water quality, destroys bottom habitat by sedimentation, and possibly reduces or eliminates food/habitat resources for both commercially and recreationally important species. These effects have both short and longer term consequences. A continuing conflict of values between waterborne commerce interests and environmental interests is likely over the extent of dredging.

Specific Problems

The following representative specific problems illustrate the distribution and variety of dredge and fill problems. The information has been furnished by Regional Sponsors.

Gulf Intracoastal Waterway (ASRs 306-309, 803, 1201-1205, and 1503)

The Gulf Intracoastal Waterway extends along the Gulf of Mexico from Apalachee Bay, Florida, to the Mexican border. Dredge and fill problems are reported for the Louisiana and Texas sections. In the Louisiana section maintenance of the waterway requires approximately 900 acres for disposal of dredged material each year. The use of wetlands as disposal areas results in loss of fish and wildlife habitat. Existing disposal areas are used as long as possible since rights-of-way for new disposal areas are difficult to obtain.

Upper Mississippi River (ASRs 701-705)

A major land use conflict along the main stem of the Mississippi River concerns dredge spoil disposal. Deposition of dredged materials and natural siltation in sloughs, backwater areas, wetland areas, fish and wildlife habitat, and rivers and streams is creating problems. Conflicts exist between Federal and State policies on dredging techniques and placement of dredged materials. Continuing channel maintenance, dredging operations, and navigational practices on the Mississippi River are based on the single criterion of navigation system efficiency. Environmental and social costs of the waterway system are not reflected in funding to maintain the system. Present Federal and State funding is inadequate to deal effectively with disposal of dredged materials and other dredging-related problems.

Great Lakes (ASRs 401-408)

There are several areas of the Great Lakes Basin with serious dredge and fill problems. Winter conditions and inadequate depths limit the navigation season and have an economic impact on the region by causing increased transportation costs of land-based commerce, stockpiling of raw materials, and an inefficient use of the existing vessel fleet and related facilities.

Dredging is necessary for the maintenance of the existing navigation system. However, the environmental impact of dredging in terms of degrading the bottom benthic biota may be significant. Disposal of dredged polluted sediment causes disruption of the aquatic environment by increasing the turbidity and smothering benthic organisms. Pollutants are resuspended in the nearshore area, causing decline in recreational and environmental values. On the other hand suspension of dredging activities would result in obvious adverse economic consequences. Conflicts exist between Federal and State standards and policies regulating dredging and related disposal activities.

Oregon Coast (ASR 1705)

Dredging for navigation in the Columbia River estuary, Coos Bay, and Yaquina Bay damages fishery habitat and degrades water quality. The disposal of dredged material has affected wildlife habitat. Effects on biological production can be particularly severe in Coos Bay and Yaquina Bay where oxygen-demanding organic deposits, resulting from pulp and paper waste discharges, are freed by dredging. Toxic products of decomposition also are released from bottom deposits.

Sacramento River (ASR 1802)

Deposits of sediment, debris, and snags interfere with navigation, recreation, and fish spawning areas and make continuing expenditures necessary for dredging and channel clearing on the Sacramento River. Continued bank and channel erosion will cause continued hazards to small boat navigation and require added costs for dredging and channel clearing.

Lower Tombigbee River and Mobile Bay (ASR 308)

This problem area lies in southwest Alabama in the Coastal Plain Province. Major water resources are the Tombigbee, Tensaw, Escatawpa, Styx, and Mobile Rivers; Mobile Bay; and the Gulf Intracoastal Waterway. Sediment loads reaching navigation channels reduce navigation depths and dredging is necessary to remove these materials. As new channels are constructed it is becoming necessary to build artificial islands in Mobile Bay to dispose of dredged materials. Proper control of material at disposal sites is difficult and presents problems in protecting the water quality of Mobile Bay. In highly developed areas it is difficult to find disposal areas within an economical pumping distance. Competition for land has resulted in the dredging and filling of low areas to develop suitable industrial sites near navigation facilities. The lack of control of these operations results in conflict of land uses and destruction of wetlands which are valuable for fish and wildlife habitat.

Options for Resolution

Erosion control on the land and along river banks can lessen the sediment deposition in streams and harbors. Reservoir releases can assist in transporting of sediment. Sediment collection systems can help by concentrating the accumulations to limit widespread dredging.

Depths of navigation channels could be limited to that sufficient to safely accomodate the vessels which will regularly use the waterway. Increased flows can reduce the need for dredging.

Disposal sites can be chosen to minimize environmental and fish and wildlife damage. A review of potential sites to evaluate their economic and environmental advantages and disadvantages could lead to an improvement in disposal policies.

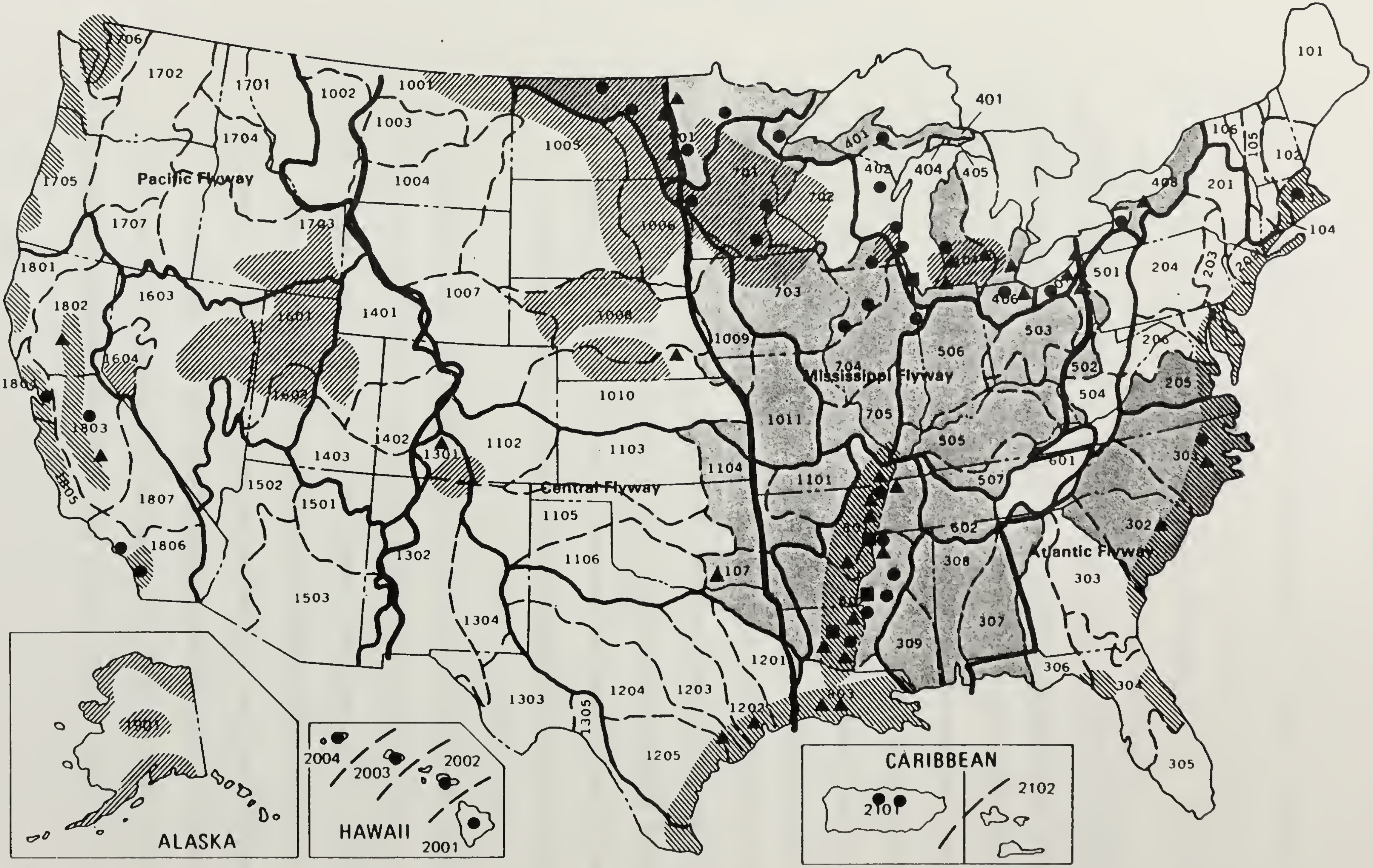
DRAINAGE

Problem Definition

Water standing on land can be a problem or a benefit. Such land is usually referred to by agriculturalists as having wet soils and by fish and wildlife interests as wetlands. However, these terms are not identical. Lands are classified by agriculturalists as having a wetness hazard if, under natural conditions and without regard to their present status, they are permanently or seasonally covered by water or are waterlogged. Thus, drained land being farmed is still considered to have a wet soils problem because, if the drainage facilities are not maintained, the land will return to its previous wet condition. Of the approximately 400 million acres of wet soils, about 100 million acres have been turned into cropland by drainage. Another 70 million could still be converted, with the remaining 230 million offering little potential for cropland (Figure II-9).

On the other hand, only a portion of the lands that have permanent or intermittent water cover are considered to be of significant value to fish and wildlife. These wetlands provide food and cover for migratory birds, wildlife, sport and commercial fish, and other forms of life, including endangered species. Waterfowl depend on wetlands for breeding and wintering habitat, particularly along the four major waterfowl migration routes. Some wetlands store ground and surface water and they control erosion; produce timber; act as fire breaks; and provide minnows,

Drainage



Legend

Areas with Greatest Total Impact

Areas with potential drainage of 50,000 acres or more for crop production.

Location of Specific Impacts

Wetland waterfowl breeding habitat needing protection.

Wetland waterfowl wintering habitat needing protection.

▲ Agricultural drainage problems.

■ Urban drainage problems.

● Loss of natural wetlands.

Figure II-9

marsh hay, wild rice, blueberries, cranberries, and peat moss. Estuarine marshes and tidal flats are productive habitats for mammals, birds, small animals, and plants. Marsh habitat includes small creeks and pools where shellfish and finfish thrive. This relationship between the land and major water bodies is important to the life cycle of commercial and noncommercial fish and wildlife.

At least 127 million acres of wetlands were found in the contiguous 48 states in the early years of this century. By 1954, nearly 40 percent of those wetlands had been drained or filled. Between 1955 and 1975, an additional six million wetland acres were drained or filled. One-half of this area had significant value to waterfowl. These lands were drainage or filling for agricultural, residential, and industrial uses or for highway, navigation, water supply, or other construction projects.

Wetlands are found in every State. The principal areas of wetland waterfowl habitat are: breeding areas of Alaska; glaciated prairie pothole region in the North Central States; saline and fresh marshes of the Great Basin region; Mississippi flyway habitat in Michigan, Wisconsin, Minnesota, and Iowa; and central flyway habitat in Nebraska and Colorado. Important wetlands for wintering birds include the Sacramento and San Joaquin valleys in California, Atlantic coastal habitat, California coastal habitat, the Mississippi Delta bottomland hardwood area, Texas coastal habitat, Louisiana coastal marshes, and Washington and Oregon coastal habitat. Hawaii's limited wetlands are especially important for endangered species.

The Second Assessment indicates that over 10 million acres of potentially good agricultural land that now has a wet soil problem will probably be drained and converted to cropland by the year 2000. About half of this land is in forest. Continuing production of food and fiber for the growing domestic consumption and export will make such conversions profitable. There is no direct correlation between lands with a wet soil problem and wetlands of value to fish and wildlife.

Highway construction on the prairies threatens important potholes which provide breeding and resting areas for migratory waterfowl. Water projects frequently cause the permanent loss of wetlands through flooding, draining, or filling with dredge soil materials.

Wet soils restrict residential, commercial, transportation, and recreational development. Low, flat land with a wet soils problem can provide an excellent location for various types of development if drained and protected from flooding. Drainage can increase woodland productivity. Accessibility for harvest, improved species, increased seedling survival, and improved growth rates can result from wetness control.

Inherent conflicts between drainage and the need to preserve wetlands for fish and wildlife require a thorough evaluation of the economic, social, and environmental effects of any proposed change to wet soils or wetlands.

Implications

Wetlands are found in every State. In the North Central, Midwest, Mississippi Delta, and Eastern Coastal Plain States some of these lands can be drained and converted to productive cropland. In this Assessment, the 10 million acres estimated to be converted to cropland through drainage are located in 30 of the 106 aggregated subregions in 10 of the 21 regions.

The Department of Agriculture 1967 Conservation Needs Inventory identified a total of 631 million acres of Class 1, 2, and 3 land. The 1975 Water Assessment estimates about 422 million acres of cultivated cropland of which 304 million are harvested. It appears that some of the 120 million acres of additional land could be cropped if required by the economy. However, every year about two million acres of farm land are being "irreversibly" lost to urban and other development while another one million acres are being inundated by ponds and reservoirs. Although the supply of cropland is currently sufficient, it is finite.

Drainage is an important farm management tool. Draining of intermittent wetlands interspersed with cultivated lands allows farmers to use equipment more efficiently. Large level dry fields are less expensive to farm. Land converted from wetlands usually grows high value crops such as corn, soybeans, cotton, peanuts, tobacco, feed grains, and wheat. Draining land gives farmers greater flexibility in the choice of crops to grow; provides a longer growing season by allowing earlier spring planting; and harvesting is not as likely to be delayed or hurried because of wetness. Water management also increases production from woodlands.

A recent study found that improved drainage on existing cropland would increase production by an amount that would otherwise require the farming of additional land and 160 million gallons of additional fuel each year.

Urgency of drainage needs is primarily related to specific local situations. Drainage can be urgent for the individual farmer who has an opportunity to raise additional crops and make a greater profit or avoid a loss. It can also be urgent in a community faced with residential and commercial damage from high water.

Most land to be drained for crop production is not wetland in the context of fish and wildlife habitat. Most of it will be level lowland with high crop production capability and much will already be in cultivation. The U.S. Department of Agriculture's Soil Conservation Service has a policy of providing assistance for draining Class 1 and 2 lands only. No assistance is provided for draining Class 3 through 20 lands. These are the lands that are more wet and rugged. Drainage would be more expensive and crop production less per dollar of investment.

Drainage also helps to control health problems that result from standing water, such as schistosomiasis and mosquito borne diseases like encephalitis. Drainage reduces the number of flies and mosquitoes with their health and nuisance problems. It also facilitates on-land disposal of waste materials that require air and bacterial action for their destruction.

However, continued loss of crucial wetlands will result in a reduction in migratory waterfowl population and other wildlife using those areas. Several endangered species and a valuable part of the ecosystem would be lost.

Wetlands comprise only a small percentage of the United States, but their loss would have an effect much greater than their limited size would indicate. For example, Iowa formerly had a million acres of wetlands and produced 3 to 4 million ducks annually; Iowa now has about 50,000 acres of wetland and produces 50,000 to 100,000 ducks per year.

The urgency of need to protect wetlands varies with the productiveness, threat of loss, and specific uses of the area. Hawaiian wetlands are crucial to many endangered species and must be protected to avoid the loss of this particular wildlife. The Fish and Wildlife Service has established a priority list of those wetlands most urgently needing protection.

The potholes region of the North Central States comprises 10 percent of the U.S. wetlands, but produces 50 percent of the ducks in the contiguous states. The Fish and Wildlife Service reports a statistically significant correlation between the number of potholes containing water and the annual continental duck population. Production is significantly reduced in years of below normal precipitation in the potholes region. As a consequence, there are fewer birds in the fall flight, bag limits are restricted, fewer hunters hunt, fewer duck stamps are sold, and fewer birds are available for bird watching. Drainage of potholes is the equivalent of a permanent drought.

Specific Problems

The following representative problems were chosen to illustrate the variety and distribution of drainage and wetland problems. The information was furnished by Regional Sponsors.

Lower Cape Fear (ASR 301)

The problem area encompasses the lower Cape Fear and New River Basins in southeastern North Carolina. Excess surface and subsurface waters prevent use of agricultural land for production of food and fiber. Upland areas with excess moisture must be drained to improve agricultural production. Conversion of some of this land may be in conflict with its best use. There is a lack of land use control and management programs.

Substantial acreage has already been drained and made available for agricultural production and other uses. In this area of over 3.5 million acres, approximately 628,000 acres have a drainage problem. This includes 468,000 acres in the Black and northeast Cape Fear River Basins, 100,000 acres along the coast, and 60,000 acres in the lower Cape Fear Basin. Average annual agricultural production losses are estimated at approximately $1,760,000 in 1967 dollars.

Maumee River Basin (ASR 406)

The Maumee River stretches 134 miles from the Fort Wayne, Indiana, northeast to Maumee Bay on Lake Erie just south of Detroit, Michigan. Soil in this area drains poorly and agricultural lands are subject to increased flood damages and impairment of drainage systems. Poor surface drainage limits use of land for agricultural or urban purposes. Drainage systems and stream channel modification cause wildlife habitat loss, increase runoff and erosion, and alter downstream flood stages.

In the period 1985-2000, overloaded tile drains in agricultural land will intensify as a problem.

Park River Basin (ASR 901)

The Park River Basin covers 1,000 square miles in northeastern North Dakota. Excess water stands on the area's flat agricultural land posing serious problems to agriculture. Floodplain and wetland areas are being converted to agricultural and urban uses. Agricultural production is reduced as a result of excess wetness which interferes with farming operations by increasing costs, delaying planting, and reducing the quantity and quality of crops produced. Waterfowl habitat is being reduced by drainage of wetlands.

There is an expansion of crop and livestock production as a result of wetland drainage and the conversion of floodplain areas to agricultural uses. There has been an expansion of the local tax base as a result of agricultural and urban development in the floodplain and wetland areas.

Lower Minnesota River Basin (ASR 701)

The Lower Minnesota River Basin problem area includes 6,500 square miles in south-central Minnesota southwest of Minneapolis. There has been extensive drainage and filling of wetlands, lakes, and ponds to facilitate agricultural development. This has caused a continuing deterioration and reduction of fish and wildlife habitat and wetlands and degradation of stream banks, scenic amenities, and other environmental resources. The natural setting of the Minnesota River Valley is being altered. There has been an expansion of crop and livestock production as a result of the drainage and filling of wetlands and the conversion of shoreland, floodplain, and forest areas to agricultural uses. The local tax base has been augmented.

Mermentau River Basin (ASR 803)

The Mermentau River Basin problem area is located in southwest Louisiana and covers the area of the Mermentau River below Iota, Louisiana, an area of 2,335 square miles.

The coastal marshes in the area are a valuable environmental resource. However, water levels vary seasonally and do not attain optimum levels for fish and wildlife productivity. Water level management is needed for maintaining vegetative development and water chemistry conducive to high productivity of fish and wildlife. High water levels in the problem area during the spring and summer prevent germination of favorable vegetative species for fish and wildlife, while low water depths during other parts of the year reduce the availability of habitat to wintering waterfowl. The production of prime waterfowl food plants such as annual grasses and sedges has decreased substantially. The major cause of this decrease is high water levels in the marsh which are maintained to produce a water supply source for rice irrigation but prevent germination of favorable species for wildlife during the growing season. High water levels in the basin have led to the proliferation of water hyacinths that degrade marsh pond habitat and impede commercial and recreational access. High water levels have also reduced the growth of soil binding plants along lake margins, leaving the shoreline soil exposed and vulnerable to wave erosion. Such erosion has been prominent in the Grand Lake and White Lake area. During low rainfall months, runoff from the Mermentau Basin is inadequate, and supplemental water is needed for water level management in the marsh for maximum productivity of fish and wildlife.

Limited fish and wildlife productivity due to water level management favoring agricultural development, adversely affects commercial fishing and trapping and sport fishing and hunting in the area. Without comprehensive water level management, erosion and poor growth of needed vegetation will ultimately destroy the valuable marshland and fish and wildlife habitat. It is estimated that the loss in harvest of white shrimp is about 1.1 million pounds annually, and blue crabs about 224,000 pounds annually. Commercial fishing and hunting have historically been significant industries that have strongly influenced the economic and social lives of the residents in the Mermentau River Basin. Deterioration of these industries will not only adversely affect the local economy but would also change the way of life of the residents.

In addition, there is inadequate drainage on 720,000 acres of cropland and pasture. On this land, drainage improvements would increase land values and the net income from agricultural production by increasing yields due to a more favorable plant environment, increased operating efficiencies, and shifts in cropping patterns. The acreage with inadequate drainage is projected to increase to 770,000 acres by the year 2000 if preventive measures are not implemented. Inadequate drainage produces a poor plant environment, increases operating costs, and reduces agricultural yields.

Rio Grande Closed Basin (ASR 1301)

The problem area is the Closed Basin of the Rio Grande headwaters in south-central Colorado near the New Mexico border. The area lies north of the Rio Grande and the surface runoff does not flow into the river. The lower part of the Closed Basin has high water tables that have encroached upon croplands and encouraged the growth of phreatophytes. There are estimated to be 371,800 acres of phreatophytes which nonbeneficially consume 415 million gallons per day. These lands need to be drained in order to return to production the formerly cropped lands and to salvage water that is now being nonbeneficially consumed by the phreatophytes and evaporation.

Tulare Lake Basin (ASR 1803)

Generally, in the trough of the Tulare Lake Basin, concentrations of salt accumulate in the upper layers of the soil. This accumulation is concentrated because of poor external drainage, and evapotranspiration by the plants concentrates the salt in the water as the water penetrates the soil profile. Although the 1.6 million tons of salt being added annually is a relatively small amount compared to the total salt load of the basin, this small increment is beginning to cause problems in the producing agricultural areas. In addition to a salt problem as lands are developed, perched water may prohibit sufficient leaching by irrigation waters to remove the salts unless satisfactory drainage facilities are in operation.

In the mid-1960s, on-farm tile drainage systems became necessary in western Fresno County. In 1975, 6,000 acres are being drained by a tile system. In all there are 27,000 acres presently requiring some type of drainage control including areas with highly saline water.

San Joaquin Basin (ASR 1803)

The problem of the San Joaquin Basin is generally not one of salt accumulation within the basin, but rather a salt level problem in the main stem of the San Joaquin River.

Associated with salt problems and high water in root zone and agriculturists' efforts to drain their land is the problem of disposal of the agricultural waste water. The total area which is at least partially drained by some type of ground water control system equals about 280,000 acres. Of this total approximately 81,000 acres are areas with highly saline water. In 1975, there were 50,000 acres with a tile drain system. New installations are proceeding at the rate of about 4,000 acres a year.

Looking at the overall problem area in the San Joaquin Valley, the magnitude of the drainage problem in the future can be evaluated by the anticipated increased acreage requiring control measures. In 1975, 600,000 acres were suffering some type of productivity loss or had required shifting more salt-tolerant crops. By the year 2000, the total is expected to increase to about one million acres.

The greatest economic impact of not providing adequate drainage would be loss in land productivity. Counties in this area account for about half of the State's total agricultural production. Preliminary studies have estimated an annual equivalent loss of $37 million. Based on estimates by leading financial institutions that $1 of gross farm income generates an additional $4 of economic activity in California, the $37 million reduction in gross income for the problem area would amount to $148 million.

Lowering shallow ground water tables would reduce marshy or swampy mosquito breeding areas; this would produce an estimated capital savings in mosquito abatement costs in excess of $3 million--at 1967 cost levels.

Other benefits could be derived from the emerging drainage issue in the area of increased wildlife habitat. If land were permitted to revert back to natural conditions, additional acres of valuable habitat would be reestablished stemming the now dwindling total. With or without large-scale drainage and disposal measures, ponding and/or transportation of drain water could be highly beneficial, especially for wild fowl, providing the use of insecticides is rigorously controlled.

The seasonal and permanent marshes (wetlands) in the basin are particularly vulnerable to development of urban, industrial, and agricultural land uses. This is a critical problem because this habitat is already in short supply through past reclamation activities. The loss of wetlands will occur on privately-owned lands as economic factors play an increasing role on land use changes.

Options for Resolution

There are many methods of water level management. The specific method to be applied depends upon the local situation and need. Moderately wet soils can be drained by subsurface tile drains or by surface ditches. Larger areas and those with larger amounts of water to dispose of usually require some type of large canal to collect the water from individual fields and convey it to a disposal area. Low wet areas can also be reclaimed by levelling such an area with the surrounding land. Farm operators accomplish drainage as a normal part of their crop land preparation. Federal and State agencies can assist the process by giving financial and technical aid and by providing major drainage outlets.

The parallel problem is to protect valuable wetlands while providing for the drainage of those agriculturally valuable farmlands. Major steps have recently been taken to protect wetlands from federally-supported projects. Executive Order 11990 requires Federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands in carrying out their programs. In addition, Federal purchase of wetlands is being given additional support.

One major problem is the inadvertent drainage of wetlands by the construction of highways with their drainage systems. Adjacent wetlands are frequently drained into these convenient outlets. Prevention of this type of use of highway right-of-way could protect important wetlands. Financial incentives can also be used to encourage private land owners to retain wetlands.

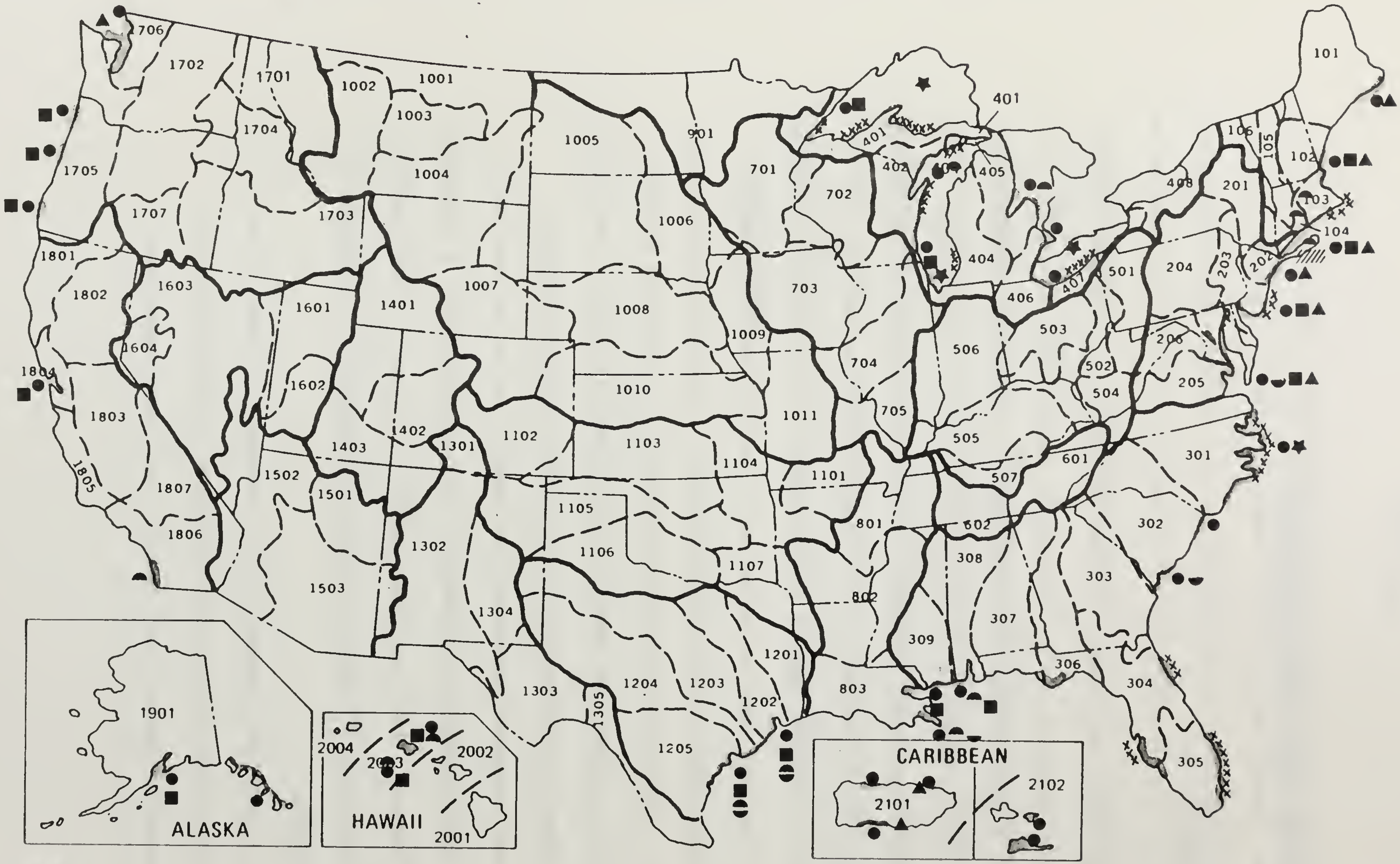
BAY, ESTUARY, AND COASTAL WATERS DEGRADATION

Problem Definition

Bays, estuaries, and coastal waters are extremely important to the economy and well being of the nation because they contain the major transportation routes for international commerce, essential habitats for fishery and wildlife resources, and the site of major recreational opportunities for more than 80 percent of the nation's population (Figure II-10). Commercial fisheries, sport fishing, waterfowl hunting, and other wildlife all depend heavily on the health of the bays and estuaries. Furthermore, tidal wetlands are valuable for natural waste treatment systems, nursery grounds, and flood absorption. Most bays and estuaries have relatively slow flushing rates that limit their capacity to handle large amounts of sediment and domestic and industrial wastes. Pesticides and related industrial wastes as well as heavy metals are readily absorbed on fine suspended sediments that settle out in the bays and estuaries. Unfortunately, these sediment traps also provide a reservoir for toxic substances, which are then available to aquatic life indirectly through the food chain or directly through resuspension of sediments by storms or dredging.

The most significant problem is the discharge of domestic and industrial wastes into the bays and estuaries, particularly in the densely populated Northeast, Mid-Atlantic, and Great Lakes areas.

Bay, Estuary, and Coastal Waters Degradation



Legend

Areas with Greatest Total Impact

Areas that have major bay or estuarine water-related problems.

Location of Specific Impacts

- ● Increased pollutant loadings from upstream or shoreline point sources.
- ■ Increased pollutant loadings from nonpoint sources.
- Increased pollutant loading from commercial and waterborne traffic-related spoils.
- ★ Increased nutrient loading as a result of human activities.
- Loss of marsh and related wetlands habitat.
- Decreased fresh water flow due to increased upstream consumptive use or diversion.
- xxxx Shoreline erosion.
- ///// Offshore dumping.

Figure II-10

Increased nutrient loadings are inseparable from domestic waste discharges, since nutrients result from organic matter decomposition, whether in the natural waters or in waste treatment plants. Some areas have had to resort to expensive tertiary treatment. This will probably become an even more persistent problem as population continues to increase in coastal areas.

Eutrophication of bays, canals, and estuaries causes algal blooms, noxious weed growth, high oxygen demand, odor, and, in the Great Lakes, taste problems in freshwater supplies. Nutrient additions also result from non-point agricultural runoff and poorly functional septic systems in urbanizing areas not served by central waste treatment facilities.

Because of a lack of economical onshore disposal sites, dumping of wastes offshore, particularly in the major coastal metropolitan areas of the Northeast, has become a common practice. This has caused serious degradation of marine and shoreline habitat. Increasing oil and debris have been accumulating on shores, threatening shoreline habitats, valuable fishing grounds, and recreational areas.

The next most significant cause of the degradation of bays and estuaries is erosion and the resultant load of suspended sediment carried into the lower reaches of the tributary rivers and into the bays where the suspended solids settle out. Erosion and sedimentation are natural wherever there is flowing water, but poor agricultural and forestry practices and construction that neglects erosion control have greatly exacerbated the problem. Besides the obvious cloudiness of the waters, the sediments cover otherwise productive shellfish beds, affect benthic communities, interfere with spawning grounds of certain fish species, reduce navigation depths, and limit water contact recreation such as swimming and scuba diving.

Dredging is required not only because of sedimentation in the channels, but also because of the requirements of larger and deeper draft vessels of today's modern fleets. Dredge material disposal has become a major problem because it is now recognized that marsh and wetlands, traditional repositories for these materials, are extremely valuable for fish and wildlife and consequently are being protected from destruction caused by filling. To curtail once extensive loss of wetlands, particularly in connection with dredging and filling operations, many States have adopted legislation to curtail this practice.

Toxic substances such as pesticides and heavy metals are also resuspended when the bottom sediments are distributed.

Many coastal areas report significant erosion problems. While most of these are related to natural causes, some areas have experienced sand dune destruction as a result of building on beaches and barrier islands. Many barrier islands are valuable wildlife preserves. They also protect coastal areas from storms and erosion.

Stabilization of shorelines is extremely expensive, particularly in dynamic coastal areas. Areas with heavily developed beaches have substantial property to protect. However, with few exceptions, attempts to stabilize sand shifting have not been successful over long periods. Subaqueous sand and gravel mining now taking place along New York and New England coasts, is expected to spread farther along the coast. This may compound the difficulty of maintaining the shoreline.

Decreased freshwater inflow to the estuaries is characteristic of the more arid regions such as the Texas Gulf coast and lower California. Altered flows may also occur where water diversions are made to other watersheds or home site developments. These modified flows alter the natural salinity regime and change the flushing characteristics of the estuary. When natural estuarine circulation is altered, major changes in populations, particularly those that are sensitive to specific salinity/topographic relationships can be expected.

Increased environmental awareness has caused planners and managers in coastal regions to critically review plans and proposals for new activities in coastal waters, particularly in relation to deepwater ports, floating nuclear power plants, and other energy-related facilities. With more concern for improved management of this coastal area within the 200-mile limit, appropriate balance between economic development and protection of the limited resource base will receive increasing attention.

Should substantial quantities of oil or natural gas be found, off-shore demands will increase for port, distribution, and refining facilities.

Implications

Untreated and inadequately treated domestic wastes introduce enteric bacteria and viruses into the bays and estuaries where they contaminate fish and shellfish and make some local areas unfit for water contact sports. The threat to public health is avoided only by the closure of contaminated areas to the taking of fish and shellfish or swimming.

Already many thousands of acres of shellfish grounds have been closed resulting in a loss of livelihood for many watermen and high prices for the remaining resource.

Industrial wastes such as insecticides, polychlorinated biphenyls (PCB's), and heavy metals all have public health implications since they can be concentrated in fish or shellfish far above the concentrations in the water. Public health implications have resulted in closure of many areas, and failure to solve this problem will undoubtedly result in further closures. With the introduction of hundreds of new organic chemicals every year, the cost of monitoring and enforcement of public health laws is likely to increase substantially if contamination of the water is not controlled at the source.

Most bays and estuaries and some barrier beaches and shorelines in populated areas are already under stress from domestic and industrial wastes, sedimentation, dredging, filling of marshland for dredge spoil disposal or development, or poor management of barrier islands and shorelines. Without marked progress in pollution abatement and land-use management, both aesthetic and ecological aspects of environmental quality may continue to be degraded.

Continued degradation of bays, estuaries and coastal waters threaten an approximately $1 billion dollar annual commercial fishery and probably greater value recreational fishery. With few exceptions, these fisheries are dependent upon the quality of water and habitat in bays and estuaries. Total U.S. landings of fish and shellfish has remained about constant in the past 20 years, but landings of fish for human consumption have decreased. Industrial fish landings have increased to make up the difference.

Severe marine transportation dislocations can occur if major ports and their access channels cannot be dredged to appropriate depths for the accommodation of modern deep draft vessels. However, disposal of dredged material without appropriate environmental consideration will adversely affect sport and commercial fishing through habitat degradation or loss.

Beach and shore erosion are natural occurrences, but severe economic problems can result from improper coastal development. The cost of beach replenishment along resort areas is enormous but necessary to these popular recreational resorts.

If substantial quantities of oil or natural gas are found on the Atlantic Outer Coastal Shelf, the national dependence on foreign oil and the balance of payments could greatly improve. On the other hand, ports in frontier areas have expressed concern over the effects on the marine and estuarine environment as well as related land issues. The costs of planning, managing, and meeting new demands for facilities are a great concern, particularly to localities that may not possess an adequate tax base to provide front end investments for anticipated economic benefits.

Fisheries and wildlife resources are dependent upon quality habitats. Larval and juvenile stages are particularly sensitive. The key to successful fishery and wildlife management is maintenance of appropriate water quality and other environmental factors in spawning, nursery feeding, and transit areas.

There are no major international implications regarding degradation of bays, estuaries, or coastal waters of the U.S., with the possible exception of the Great Lakes region where the U.S. and Canada must cooperate on water quality management and pollution abatement. On the other hand, a problem may develop if international agreements reached in the context of the U.S. 200-mile fishery zone guarantee to a foreign nation a minimum catch of an estuarine or bay dependent species and the production of that species is adversely affected by degraded bay, estuary, or coastal environments. Almost all bays and estuaries in urban, agricultural, or urbanizing areas are affected by point or non-point pollution. Almost all coastal States have bay, estuary, or coastal systems that have been subject to dredge and fill operations with resultant loss of fish and wildlife habitat.

In many of these regions, the economic gain because of increased industrial and commercial development spurred by these activities has outweighed the economic loss. However, with a reduction in suitable fish and wildlife habitats, the potential benefits of this type of alteration have been severely diminished to the point that most coastal States have active regulatory programs to discourage further wetland alteration.

Fresh water diversion, with the exception of the Texas Gulf Coast region, is not a regional problem but is of concern between river basins and their associated estuarine systems in many regions as planners and managers attempt to alleviate local freshwater supply shortages by interbasin transfers.

The degradation of bays and estuaries and the coastal environment is insidious. It has developed over a long time with gradually increasing demands and pressures being exerted by increasing populations, a higher standard of living, increasing conflicts of use, new products in manufacturing and agriculture and increasing use of pesticides. While populations and demands increase, the carrying capacity of estuaries remains fixed. It is the concensus of the scientific community that the carrying capacity of many major bay and estuarine systems has already been reached.

Specific Problems

The following representative specific problems illustrate the variety of estuary and coastal problems. Regional Sponsors provided information upon which to base the problem analysis.

Potomac River (ASR 206)

The problems of domestic and industrial waste disposal are ubiquitous. Nutrient loading is common to all areas. For example, the tidal Potomac River is exhibiting signs of eutrophication from the Washington, D.C. metropolitan area some 50 miles below the city.

Mid-Atlantic Coast (ASRs 202 and 203)

The sludge disposal problem in the Mid-Atlantic states is particularly acute. Several localities, including New York City, Philadelphia, and some New Jersey communities, are under federal regulatory strictures or court injuntions to limit or curtail the disposal of waste in the Mid-Atlantic Bight.

James River, Virginia (ASR 205)

The most recent and widely publicized problem related to industrial waste discharge is that of Kepone in the James River, Virginia. Present evidence indicates that Kepone (a chlorinated hydrocarbon used in pesticide formulations) was discharged for several years into the James River before regulatory agencies became aware of the problem. As a result, the James River is now closed to fishing some 70 miles below the plant manufacturing Kepone.

Although site-specific problems, such as Kepone, receive widespread attention, a more pervasive and economically severe problem is the closing of shellfish harvesting grounds because of high fecal or total coliform counts in parts of most bays and estuaries.

Northeast Coast (ASR 103 and 104)

Loss of marshland is a ubiquitous problem; however, the major impacts have occurred in areas with heavy populations concentrated in coastal regions such as the Northeast.

For example in the Northeast since 1900, Connecticut has lost 40 percent and Massachusetts 20 percent of its wetlands. In Long Island during a 10-year period between 1955 and 1964, 30 percent of the coastal wetlands were lost.

The severity of this problem has been recognized and now almost all coastal states have effective wetlands protective legislation.

South Carolina (ASR 302)

The problem of decreased fresh water flow is best exemplified by the situation in South Carolina where severe problems of siltation and the associated costs of dredging have generated a plan to redivert water presently flowing through the Cooper River back to the Santee River.

The principal problem facing South Carolina is that a viable shellfish industry in the mouth of the Santee River may be lost and, of more immediate concern, fresh water supplies to industries located along the fresh water portions of the tidal Cooper River may be contaminated by salt water intrusion.

Hatteras Island (ASR 301)

Shoreline erosion is a common problem. In many regions the economic magnitude of the problem is underestimated because the impact is borne by small property owners. An example of the difficulty and economic cost of stabilizing shorelines is provided by experience of the U.S. Government which invested over $18 million from 1930 to 1973 in attempting to stabilize the shoreline of Hatteras Island, North Carolina, before the National Park Service adopted a policy of letting nature take its course.

Great Lakes (ASRs 401-408)

The Great Lakes Region experiences severe shoreline erosion as a result of high water levels and wind-induced wave action.

Cape Charles, Virginia (ASR 205)

Although not quantifiable in precise economic terms, the public costs of onshore actions to support offshore oil and gas development in frontier areas is considered to be substantial, particularly by localities that may have to bear a heavy expenditure of public funds for services prior to realizing a return of tax dollars from the build up activities. A prime example of this is the planned establishment of a major off shore structure fabricating facility at Cape Charles, Virginia, an underdeveloped rural area with a severe shortage of skilled labor.

Local government is expecting a major influx of skilled workers and increasing demand for local services that will far exceed initial tax returns.

Chesapeake Bay (ASR 205)

Large quantities of materials that are potentially hazardous are transported through bays and estuaries and accidental spills are common. A typical example is the sinking of an oil barge in Chesapeake Bay in February 1976 with the spill of 250,000 gallons of No. 6 oil. Some 20,000 waterfowl perished and 20 miles of shoreline were contaminated. Cost of cleaning exceeded $380,000.

Options for Resolution

There are few viable options for dealing with problems of degradation of bays, estuaries, or coastal waters that do not include either limitations on development and/or heavy expenditures of funds.

Because of the interrelationship of bays, estuaries, and coastal waters with adjacent areas, the problems cannot be solved without greatly increased local, State, and regional interaction.

Specific actions that would delineate options include the establishment of carrying capacities for various river basins based upon desired use of the systems that would constrain non-managed growth.

Plans for development of coastal-related resources must consider conflicts that multiple use places on the system and relate specific resource utilization plans to regional goals and objectives.

Appendix A

Names of Regions and Aggregated Subregions

WATER RESOURCE REGIONS AND SUBREGIONS

REGION NUMBER	SUBREGION NUMBER	REGION / SUBREGION
01		NEW ENGLAND
	0101	Northern Maine
	0102	Saco-Merrimack
	0103	Massachusetts-Rhode Island Coastal
	0104	Housatonic-Thames
	0105	Connecticut River
	0106	Richelieu
02		MID-ATLANTIC
	0201	Upper Hudson
	0202	Lower Hudson-Long Island-North New Jersey
	0203	Delaware
	0204	Susquehanna
	0205	Upper and Lower Chesapeake
	0206	Potomac
03		SOUTH ATLANTIC-GULF
	0301	Roanoke-Cape Fear
	0302	Pee Dee-Edisto
	0303	Savannah-St Marys
	0304	St Johns-Suwannee
	0305	Southern Florida
	0306	Apalachicola
	0307	Alabama-Choctawhatchee
	0308	Mobil-Tombigbee
	0309	Pascagoula-Pearl
04		GREAT LAKES
	0401	Lake Superior
	0402	NW Lake Michigan
	0403	SW Lake Michigan
	0404	Eastern Lake Michigan
	0405	Lake Huron
	0406	St Clair-Western Lake Erie
	0407	Eastern Lake Erie
	0408	Lake Ontario
05		OHIO
	0501	Ohio Headwaters
	0502	Upper Ohio-Big Sandy
	0503	Muskingum-Scioto-Miami
	0504	Kanawha
	0505	Kentucky-Licking-Green-Ohio
	0506	Wabash
	0507	Cumberland
06		TENNESSEE
	0601	Upper Tennessee
	0602	Lower Tennessee
07		UPPER MISSISSIPPI
	0701	Mississippi Headwaters
	0702	Black-Root-Chippewa-Wisconsin
	0703	Rock-Mississippi-Des Moines
	0704	Salt-Sny-Illinois
	0705	Lower Upper Mississippi
08		LOWER MISSISSIPPI
	0801	Hatchie-Mississippi-St Francis
	0802	Yazoo-Mississippi-Ouachita
	0803	Mississippi Delta
09		SOURIS-RED-RAINY
	0901	Souris-Red-Rainy
10		MISSOURI
	1001	Missouri-Milk-Saskatchewan
	1002	Missouri-Marias
	1003	Missouri-Musselshell
	1004	Yellowstone
	1005	Western Dakotas
	1006	Eastern Dakotas

WATER RESOURCE REGIONS AND SUBREGIONS

REGION NUMBER	SUBREGION NUMBER	REGION /SUBREGION
	1007	North and South Platte
	1008	Niobrara-Platte-Loup
	1009	Middle Missouri
	1010	Kansas
	1011	Lower Missouri
11		ARKANSAS-WHITE-RED
	1101	Upper White
	1102	Upper Arkansas
	1103	Arkansas-Cimarron
	1104	Lower Arkansas
	1105	Canadian
	1106	Red-Washita
	1107	Red-Sulphur
12		TEXAS-GULF
	1201	Sabine-Neches
	1202	Trinity-Galveston Bay
	1203	Brazos
	1204	Colorado (Texas)
	1205	Nueces-Texas Coastal
13		RIO GRANDE
	1301	Rio Grande Headwaters
	1302	Middle Rio Grande
	1303	Rio Grande-Pecos
	1304	Upper Pecos
	1305	Lower Rio Grande
14		UPPER COLORADO
	1401	Green-White-Yampa
	1402	Colorado-Gunnison
	1403	Colorado-San Juan
15		LOWER COLORADO
	1501	Little Colorado
	1502	Lower Colorado Main Stem
	1503	Gila
16		GREAT BASIN
	1601	Bear-Great Salt Lake
	1602	Sevier Lake
	1603	Humboldt-Tonopah Desert
	1604	Central Lahontan
17		PACIFIC NORTHWEST
	1701	Clark Fork-Kootenai
	1702	Upper / Middle Columbia
	1703	Upper / Central Snake
	1704	Lower Snake
	1705	Coast-Lower Columbia
	1706	Puget Sound
	1707	Oregon Closed Basin
18		CALIFORNIA
	1801	Klamath-North Coastal
	1802	Sacramento-Lahontan
	1803	San Joaquin-Tulare
	1804	San Francisco Bay
	1805	Central California Coast
	1806	Southern California
	1807	Lahontan-South
19		ALASKA
	1901	Alaska
20		HAWAII
	2001	Hawaii County
	2002	Maui County
	2003	Honolulu County
	2004	Kauai County
21		CARIBBEAN
	2101	Puerto Rico
	2102	Virgin Islands